FOOD TECHNOLOGY

PUBLISHED BY THE INSTITUTE OF FOOD TECHNOLOGISTS

IN THIS ISSUE

Utilization of Fruits in Food Products / *419*

Reconstituting Moisture in Over-dried Popcorn by Blending with Wet Popcorn / *426*

Reproducibility of Results in Consumer Wine-Preference Surveys / *431*

Rates of Nonenzymatic Browning of White Potato During Dehydration / *433*

The Effects of Low Methoxyl Pectin and Calcium Salts on the Drained Weight and Calcium Content of Processed Raspberries / *438*

Stability of Cucumber Peroxidase in Salt Stock Pickles During Fermentation, Curing, Storage, and Packing / *442*

A Household and a Laboratory Type of Panel for Testing Consumer Preference / *445*

The Particle Size of Semolina in Relation to Quality and Wheat Variety / *449*

Evaluating the Quality of Processed Foods / *453*

Packaging of Frozen Citrus Concentrates / *456*

A Study of Factors Affecting the Determination of Solids in Yeast Press Cake / *458*

Antibiotics in Food Preservation / *461*

Stability of Tomato Juice and Concentrates Held at Elevated Temperatures / *466*

A Recording Strain-Gage Denture Tenderometer for Foods. I. Instrument Evaluation and Initial Tests / *471*

Potential Application of the Rapid Scanning Spectrophotometer for the Objective Valuation of Food Color / *478*

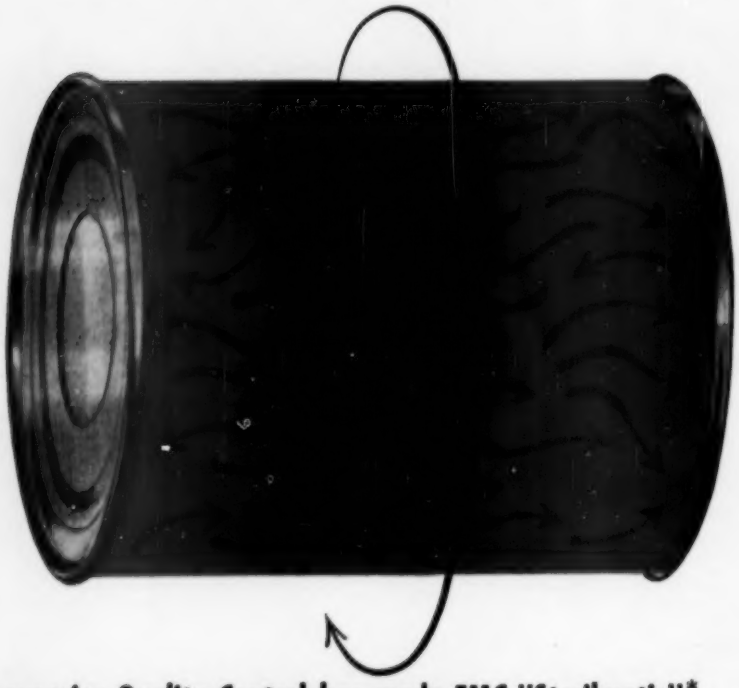
Affairs of the Institute / *2*

Food for thought:
The Future for Food Technologists
— See Affairs of the Institute

Pages 419-482

September, 1955 Volume 9, Number 9

Only UNIFORMLY CONTROLLED CAN AGITATION GIVES FAST AND EVEN HEAT PENETRATION



Compare!

Conventional non-agitation type cooking, where heating is by *conduction*, is both slow and uneven. This type of cooking makes it necessary to overheat the product at the can's periphery in order to reach sterility at the center of the can. As a result, complete uniformity of product quality within the can is seldom possible.

This superior Quality Control has made FMC "Sterilmatic"* the standard of processing equipment for finer canned foods

Within the "Sterilmatic" Continuous Pressure Cooker every can is cooked *evenly* and *exactly alike* through the combination of individual can rotation and agitation of the product within the can. Of course this rolling agitation and the consequent "basting" action depends on the consistency of the product. But the important point is that this is *induced convection heating*, which increases the rate of heat penetration, keeps cooking absolutely uniform, provides for the precise processing control you need to maintain consistently high standards of product quality.

When you compare the process and compare the results, you'll sooner or later replace with an FMC "Sterilmatic" Continuous Pressure Cooker and Cooler. So write today for full information, or call your nearest FMC representative.

NOTE: For products requiring very little agitation a special type of reel and spiral mechanism is provided.

*Trade Mark — Reg. U. S. Pat. Off.

Write for free booklets!
"The Sterilmatic Story" shows what this equipment can do for your operations. "Sterilmatic Facts" includes all technical data and specifications of equipment.

FOOD MACHINERY AND CHEMICAL CORPORATION

Canning Machinery Division

General Sales Offices:

WESTERN: SAN JOSE, CALIFORNIA **EASTERN:** HOOPESTON, ILLINOIS

DEPENDABLE COLORS
for Discriminating Buyers

- Unlimited production facilities
- Complete technical service

- Accurate blending
- Nationwide distribution

Write us for Prices and Detailed Information.

U.S.P. Vitamins in bulk
Also available in carriers for easy, accurate and economical fortification of foods.

• • •

Roccal—the original quaternary ammonium sanitizing agent.

Sterwin Chemicals INC.
SUBSIDIARY OF STERLING DRUG INC.

1450 BROADWAY, NEW YORK 18, N. Y.
2020 Greenwood Avenue, Evanston, Ill.
WAREHOUSE STOCKS: Rensselaer, N. Y., Evanston, Ill., Los Angeles
FACTORY: CINCINNATI, OHIO
Branch Offices:
Atlanta, Boston, Buffalo, Dallas, Evanston (Ill.), Kansas City (Mo.), Los Angeles, Minneapolis, Portland (Ore.), St. Louis

WORLD'S LARGEST SUPPLIERS OF VANILLIN

Affairs of the Institute

Presidential Address at Columbus
Annual Meeting Bulletin Board
Personnel
Recently Elected Members
Books
Selected Abstracts
Future Meetings
Food Industry Topics

The Future for Food Technologists

Presidential Address, Fifteenth Annual Meeting

PHILIP K. BATES, President, IFT, 1954-55

WE ARE gathered here in Columbus for the fifteenth annual meeting of our Institute. Our progress in accomplishing the objectives of the Founders has been outstanding. Our growth has been constant and healthy. But if a young man, in talking with you about his future, asks what he might expect in the way of opportunity in the field of Food Technology, what would you tell him? Why are there so few men taking the training which is being offered in this field? Is this situation due to the comparative youth of our profession? Does our profession lack glamour and publicity, or is there a real question of opportunity? I would like to give you some of my thoughts on the future for Food Technologists.

There are many reports that in view of the predictable demand there is a shortage of scientists and engineers in training. The personnel men from industry, who go from college to college recruiting from the graduating classes, almost seem to outnumber the graduates, and there are amusing stories of their resorting to hiring one another. It would be difficult to say precisely how many well-trained Food Technologists could be absorbed each year in industry, in teaching or in the government laboratories. Our Institute has about 4000 members and if we consider a work span of 40 years, we would require a hundred men a year to keep our ranks intact. I feel sure that more than a hundred could well be used—and that we are not graduating a hundred this year.

On what basis does an able student select the field he wishes to work in? As we look back to the start of our own careers, we shall find that many factors affected our decisions. If we are wiser now and so recognize the important fundamentals, we will counsel a student to seek training for work for which there is a demand, in a field where the work is needed, and where the results will justify his receiving a fair reward. As he gets to the point of seeking a job, he must look carefully at the possible industries and groups within the industry who can take him in, who can use his work, and so will be able to reward him for his contribution.

Obviously, students will not select a training in food technology unless they know it is available. Some colleges are distributing information about their food technology courses; additional attention is obtained through news releases concerning their research accomplishments or the construction of new buildings. This is all in the right direction, but our profession is up against stiff competition and we must look for more ways of making this training known, particularly at the high school level. The parents of high school students, and even the vocational advisors in the schools, have little opportunity to know what a food technologist does and thus few are adequately informed to advise it as a profession. We need to do more to make the opportunities in our profession known in the high schools.

Avenues to success. Assuming then that we are talking with a young man, whom we might interest in studying Food Technology, what are we to tell him of the opportunities in our profession? There will, of course, be some openings in teaching and research at the university level, but these openings will be few in number for a time. There will be more numerous opportunities to do research work in government laboratories, in commercial research groups or, more probably, in the research and development laboratories of industry. This industrial research is by no means confined to the laboratories of the food manufacturers themselves but also includes the laboratories of the suppliers of containers and processing equipment. There are also many openings in quality control laboratories, in processing and in technical service groups. We all know that there is a wide demand for Food Technologists.

Many young men have heard stories of unemployment among scientists during the great depression of the thirties and so are interested to know whether research and development are as essential to the food industry as are production, advertising, and selling. They may well have read the magazine stories of the growth of many of our large food companies and have the well-justified impression that their greatness has been achieved by economies of production or distribution, the popularizing of a brand name as a mark of quality, the joining together of smaller, less efficient operations, or by other means which have little to do with science, engineering or laboratory development. Fortunately, we can refer him to the talks of food manufacturers who have said that a substantial volume of their business is made up of new products which have come from the laboratory.

A company president evaluates the men of his organization by their contribution to the profits of the company. There are numerous ways in which a food technologist can contribute to a company. A few examples may illustrate some of the various possibilities.

One of the most obvious ways of increasing profit for a company is through a reduction in the cost of production and storage. The aging of meat under the protection of ultra-violet light substantially reduced the time required, as the meat did not have to be hung as long. This meant that for a given volume of sales there was a lower inventory cost and a reduction in the size of storage rooms, both of which reduce costs.

A reduction of rejects through engineering or product studies will produce more product which is salable. An oven with better controlled or more uniform heat will, perhaps, reduce the number of burned crackers. The water conveyors for fruits and vegetables reduce the injuries due to bruises or crushing. The prepackaging

(Continued on page 5)

It's time ...to ask your suppliers for IONOL®, C.P. *impregnated packaging...*

newest, low-cost way to protect foods against oxidative spoilage

When fats and oils migrate from food product to box or wrapper, they rancidify quickly, causing deterioration of flavor and aroma.

The effective way to combat this serious threat to product shelf life is to incorporate Ionol, C.P.—a most efficient antioxidant—into the boxboard or wrapping material. Rancidity is then stopped right where it begins, at the *surface*.

In actual tests, baked goods stored at 85°F in Ionol, C.P. impregnated boxboard cartons, were free of rancidity at the end of ninety days. Without Ionol, C.P. protection, baked goods stored under similar conditions, often develop rancidity within a week.

When your food products contain fats or oils, Ionol, C.P. impregnated boxes or wrappers will greatly prolong shelf life. Additional protection can be assured by using Ionol, C.P. as a direct ingredient in your food products.

Ask your packaging materials supplier for this modern way to protect the good name of your brand label. Write to Shell Chemical for names of suppliers of Ionol, C.P. impregnated packaging.

SHELL CHEMICAL CORPORATION

CHEMICAL PARTNER OF INDUSTRY AND AGRICULTURE

380 Madison Avenue New York 17, New York

Atlanta • Boston • Chicago • Cleveland • Detroit • Houston • Los Angeles • Newark • New York • San Francisco • St. Louis
IN CANADA: Chemical Division, Shell Oil Company of Canada, Limited • Montreal • Toronto • Vancouver

IT'S NEW!

Beta 'Roche' CAROTENE

Gives foods true, natural yellow color and vitamin A potency

Processors of margarine, shortening, butter, cheese, yellow baked goods, confectionery and edible oils will be especially interested in the new and exclusive product of original Roche research: beta carotene 'Roche.'

Beta carotene 'Roche' has many advantages:

NATURAL COLORING

Beta carotene is the natural coloring matter of butter and other dairy products and is a constituent of cereal grains, alfalfa, carrots, and other vegetation. 'Roche' beta carotene imparts a *true* natural yellow color without any tinge of green. It does not change to a reddish color as do some vegetable pigments during storage.

ADDS NUTRITIONAL VALUE

Theoretically, one gram of pure beta carotene is equivalent to 1.67 million U.S.P. units of vitamin A. High retention of beta carotene-vitamin A activity is achieved in baked goods and other foods when margarine and shortening containing added beta carotene 'Roche' are used.

COLOR STABILITY

Extensive laboratory data show excellent color stability of margarine, butter, shortening, cheese, edible oils and yellow bakery products which were colored with beta carotene 'Roche.'

UNIFORMITY

The high degree of purity and color stability ensures uniform and constant intensity of color when using equal amounts per batch.

USAGE

Beta carotene 'Roche' is ideal for use in the following foods because it gives them *natural*, yellow color and vitamin A potency:

Margarine	Shortening
Butter	Cheese
Yellow bakery products	Confections
Edible Oils	

Detailed information about the application of beta carotene 'Roche' is available in a technical brochure. Ask your Roche salesman or write the Vitamin Division for this publication and for samples.

TECHNICAL INFORMATION

Crystalline beta carotene 'Roche' is in the all trans form

Empirical Formula: $C_{40}H_{56}$
Molecular Weight: 536.85
Melting Point: 183.0
Appearance: Red-violet platelets

Solubility in Edible Oils:

At room temperature	about 0.08%
At 60 C.	about 0.2 %
At 100 C.	about 0.8 %

Biological Properties

0.6 microgram beta carotene: 1.0 units of vitamin A
1.0 gram beta carotene: 1,666,666 + U.S.P. units of vitamin A

PACKAGING

33-pound steel pails, double Synthetasine lined, with removable-replaceable-leverlok cover.

3-pound triple-tite tamperpruf metal cans.

Batch size cans of Vitamin A and Beta Carotene 'Roche' blended in vegetable oil to your specifications.

24% Semi-solid Suspension of Beta Carotene 'Roche'
400,000 U.S.P. units per gram 'Roche' beta carotene in vegetable oils.

call ROCHE *for vitamins*

VITAMIN DIVISION • **HOFFMANN-LA ROCHE INC.** • NUTLEY 10, NEW JERSEY
NUtley 2-5000

Pacific Coast distributor:
L. H. BUTCHER COMPANY, San Francisco
Los Angeles • Seattle • Portland • Salt Lake City
In Canada: Hoffmann-La Roche Ltd.
286 St. Paul Street, West, Montreal, Quebec

FOOD TECHNOLOGY

Published Monthly by the Institute of Food Technologists

Editor

MARTIN S. PETERSON

Editorial Office: 11606 South Bell Avenue, Chicago 43, Illinois

Consulting Editor

Z. I. KERTESZ

Editor Emeritus

C. OLIN BALL

Associate Editors

C. D. ATKINS
JOHN C. AYRES
ROBERT E. BUCK
HAROLD A. CAMPBELL
GEORGE A. CRAPPLE
WILLIAM B. ESSELEN, JR.
ROBERT E. FEENEY
DEAN FOSTER
SAMUEL A. GOLDBLITH
HELEN L. HANSON
WILLIAM R. JOHNSTON
C. HAMILTON KENNEY
AMIHUD KRAMER
HOWARD D. LIGHTBODY
WALTER A. MACLINN
R. E. MORSE
HUGH L. A. TARR
J. G. WOODROOF

ADMINISTRATIVE DATA AND DIRECTORY

Office of the Editor

11606 South Bell Avenue, Chicago 43

Address to this office all manuscripts, proofs, letters pertaining thereto, etc. Prospective contributors are invited to send for the pamphlet *Information and Suggestions to Authors* which contains style instructions.

Responsibility for statements appearing in FOOD TECHNOLOGY rests on the author thereof; points of view expressed in the columns of the journal do not necessarily have the indorsement of the Institute of Food Technologists. Mention of commercial products in the technical pages of this Journal is not to be construed as a recommendation of such products over others in the same category.

Business Manager

CHARLES S. LAWRENCE

176 West Adams Street, Chicago 3, Illinois

Address to the business office all requests for subscriptions, changes of address, and information on advertising. Claims for copies lost in the mails must be received 30 days after issue (90 days, foreign). Changes of address must be received at least two weeks before date of issue.

Subscription Rates: For members the cost of subscription is included in the annual dues. Non-members: domestic, $8.50 per year; Canada, Cuba and Mexico, $10.00 per year; all other foreign, $12.00 per year. Single and back copies: domestic, $1.00; foreign, $1.25.

Advertising Representatives: *Eastern:* Duncan Macpherson, 700 S. Washington Square, Philadelphia 6, Pa. *Midwestern:* Dale McCutcheon & Co., 154 E. Erie St., Chicago 11, Ill. *West Coast:* William A. Ayres Company, 233 Sansome Street, San Francisco 4, California.

Publication Office

The Garrard Press,
119 West Park Avenue, Champaign, Illinois

Address to the Publication Office all requests for non-member subscriptions, back volumes, single copies (costs are listed above). Authors desiring reprints should address orders to this office; rates are printed on the order blank. (Requests for a single reprint of a published paper should be addressed to the author.)

FOOD TECHNOLOGY is published by the Institute of Food Technologists and printed by the Garrard Press, Champaign, Illinois, U. S. A.

Copyright, 1955, by the Institute of Food Technologists.

Mailing Permit: Entered as second-class matter, Feb. 25, 1947, at the Post Office at Champaign, Illinois, under the Act of August 24, 1912.

THE FUTURE FOR FOOD TECHNOLOGISTS

(Continued from page 2)

of vegetables cuts losses from drying and provides a more attractive product for the customer.

The utilization of by-products is well known as a means of reducing costs. The meat packing industry has been traditionally famous for its ability to find some use for every part of the animals slaughtered. The production of furfural from oat hulls has built up such a demand that other source materials are now required.

The maintenance of high quality or the improvement in quality of a product is not as easily measured as a factor contributing to profit. In the early and uncertain days of quick-frozen foods, one large producer set up high standards for quality and maintained them. It believed that repeat business would depend on the customer being sure of the same high quality product in every package. This company is still doing a fine business. Some brands where quality varied are no longer found.

New products are also welcomed. Almost any sales manager will be happy if you offer him a product which everyone wants, which no competitor has, and which will be sold at such a low price that every customer will feel it's a bargain. Of course, he's willing to leave the production problems and profit margins to others in the company. Such bonanzas are very rare, but there have been many new food products which have gained wide acceptance. A few well-known examples would include dehydrated soups, frozen concentrated orange juice, and Instant Coffee. I am sure that thoughtful management recognizes a research or development group as an essential and worthwhile part of an organization.

The rewards. Having in mind some examples of what a food technologist may accomplish for a food manufacturing company, we should consider what he can expect for salary. Superficially, it is easy to reply that, in general, the rates of pay for food technologists are comparable with the rates for chemists, engineers, and others with comparable training. The salary a man receives is a peculiarly personal fact, so little exact information is available on this point. Promotion is well publicized and many of our group have been congratulated as they have been made department heads, vice presidents or presidents. This increase in responsibility has come through their contribution to the progress of their company and we shall assume that their reward has not been in the title alone.

A business must make some contribution if it is to continue. In the food industry much of the change or progress that distinguishes our present day food from that of long ago can be attributed to the application of science or engineering. Canning and freezing permit the storage of food for long periods and also permit its transportation over long distances. The harvest period for peas is a matter of weeks, only, but they can be purchased canned or frozen, throughout the year and everywhere in the country. The preparation of food commercially rather than in the home utilizes the ability of the food technologist more and more. The cooked

Help for the conscientious

This will introduce a new Myverol® Distilled Monoglyceride—*Type 18-06*. It's for the man who has an "all-vegetable" label to live with. No longer need he deny his product those wonderful texture effects obtainable with *Type 18-00* in shortening, baked goods, margarine, icing, and frozen desserts just because the tiny amount of it he would need is made from hydrogenated lard.

Now he can get a flake-type genuine *Myverol* monoglyceride, with all the advantage it means in economy, purity, and effectiveness—but made from hydrogenated vegetable oil and U. S. P. Standard glycerine. The only preservative is a trace of citric acid, which confers excellent stability.

Distribution of fatty acid chain lengths is not exactly the same in the new *Type 18-06* as in *Type 18-00*, the *18-00* tending to run a trifle lower in saponification number. Iodine value of *18-06* is a trifle higher. Both congeal at about 68 C. Both contain no less than 90% active mono, not counting 2-monoglycerides, which are active too.

Despite the close similarity, it is advisable to run some experiments on your products with *18-06*, even if you are already very familiar with *18-00*. If you're not, it's even more advisable.

For generous samples and helpful advice, write ***Distillation Products Industries,*** Rochester 3, N. Y. Sales offices: New York, Chicago, and Memphis • W. M. Gillies and Company, Los Angeles, Portland, and San Francisco • Charles Albert Smith Limited, Montreal and Toronto.

distillers of monoglycerides made from natural fats and oils

DPi

Also . . . vitamin A in bulk for foods and pharmaceuticals

Distillation Products Industries

is a division of **Eastman Kodak Company**

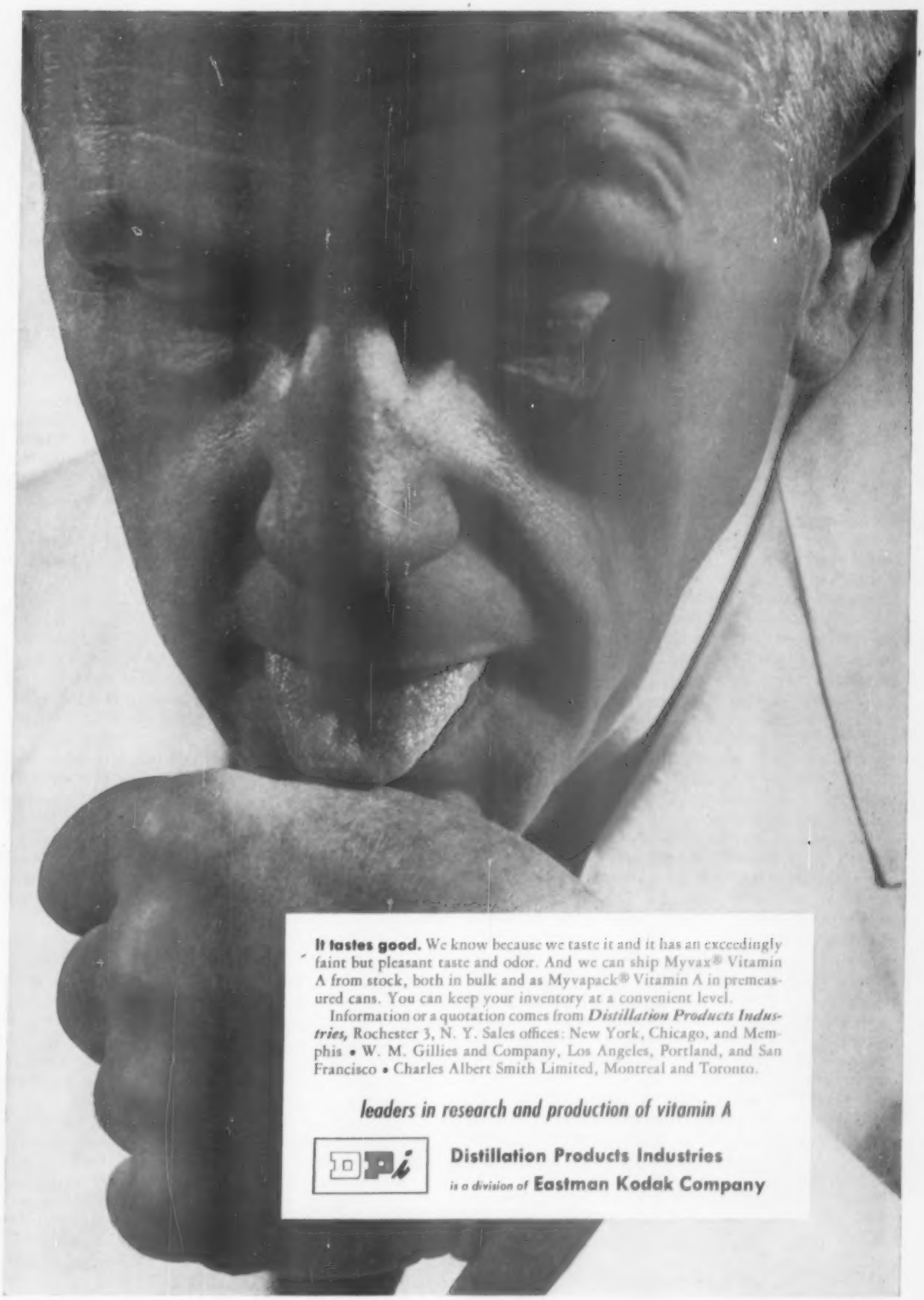
and frozen foods which only need to be warmed to be served are the result of imagination and much application of technical knowledge. The food industry will see a tremendous expansion through the development of a wider variety of precooked foods.

Let us consider the changes food technologists have made possible for the fish industry. I was brought up in Plymouth, Massachusetts, a seacoast town, and my family were very fond of mackerel. I can recall going to the wharf when a boy and buying a fine fat mackerel from the fisherman at his boat, as people have done for centuries. In particular, I remember the packaging was a piece of fish line tied around the tail of the fish with a loop on the other end of the line through which I put my finger. Nothing could be simpler, but I had only a half mile to transport the fish. To expand the business by transporting for long distances or for storage longer than until the next meal, fish were refrigerated or frozen, round. As a further step in processing, fish were filleted before they were frozen, as this cut down the tonnage to be frozen or shipped, but more important, it saved the housewife and her family the problem of bones in their fish. The filleting process was mechanized and this received one of our earlier Food Engineering Awards. The latest step in this saga is the introduction of fried fish sticks, which need only be heated and served. And the moral of this story is that processing will expand the market, with the added thought that the more the processing, the more the value added to the product and therefore the greater the profit possibility. For I'm sure that you'll agree that there is more possibility of profit in a package of fried fish sticks than there is in the piece of fish line tied around the tail of a mackerel.

We feel then that men trained as food technologists will find jobs, that the food industry can use their work, and that they seem to be well rewarded. Perhaps of even more significance is the fact that the value which their processes add to the foods gives a basis to justify their salaries. It is also apparent that many who will come into the field of food technology will have been trained in some other branch of science or engineering, but they will use their training in the food field. These men will have to choose between the food industry and one or more other industries. Is the grass greener on the other side of the fence or does the food industry get good men who have been trained as chemical engineers, mechanical engineers, biochemists, and so forth?

It is reasonable to assume that these men will carefully compare the industries they may join. They want to know whether the industry is growing and whether its growth may be affected by government control. They are interested in financial stability and they want to know whether the industry is able to make a profit year by year. It is certain that no matter how good our product, how tempting the advertising, or how much of a bargain the food may be, a person does not double his consumption or use. The population is increasing at a rapid rate and this provides a growing market, but let's face it, there is a limit in the amount of food that will be sold. This, fortunately, does not limit the growth of the food industry, for we have seen that our customers like to have industry do more and more of the

(Continued on page 8)



It tastes good. We know because we taste it and it has an exceedingly faint but pleasant taste and odor. And we can ship Myvax® Vitamin A from stock, both in bulk and as Myvapack® Vitamin A in premeasured cans. You can keep your inventory at a convenient level.

Information or a quotation comes from ***Distillation Products Industries,*** Rochester 3, N. Y. Sales offices: New York, Chicago, and Memphis • W. M. Gillies and Company, Los Angeles, Portland, and San Francisco • Charles Albert Smith Limited, Montreal and Toronto.

leaders in research and production of vitamin A

DPi **Distillation Products Industries**
is a division of **Eastman Kodak Company**

THE FUTURE FOR FOOD TECHNOLOGISTS

(Continued from page 6)

preparation and cooking of food—and this offers a tremendous growth potential for the industry.

Problems and potentials. Increasing the extent to which food is processed does have some problems. Considerable capital is required for the additional equipment required for preparation or cooking, but this is a factor that is not insurmountable. Containers that prevent spoilage or maintain sterility have required ingenuity, but this also can be worked out. There is one factor that has caused great concern to progressive food manufacturers, and this is the use of new ingredients. Laboratory workers sometimes find that a new ingredient will add a very desirable quality to a food product. In considering its use, the problem which seems most difficult of solution is how to insure the safety of the consumer. No manufacturer wishes to kill or injure his customers for he would not long have any business. It almost seems that law-makers have a special concern about the possibility of injury from foods with much less regard for dangers from other sources. For instance, few would suggest that the manufacture of automobiles should be prohibited because they kill or injure so many people every year. Yet press reports sometimes seem to give the picture that laws are needed that would prevent the use of any new ingredient in a food product unless there was absolute proof that no degree of harm would come to anyone using the food, even to excess. I feel sure that a way will be found by the food industry and regulatory groups to permit the use of new processes and ingredients after testing procedures, which give real assurance of safety but are short of the prohibitively costly test techniques which would be required for answers of absolute safety under every condition of use.

The question of financial stability varies with the individual company concerned. On the whole, the food industry is a very stable industry. A person's inability to increase his consumption of food may limit the growth of the business, but the every-day requirement for a definite quantity of food means a constant and continuing market.

The problem of profits being made by the industry is certainly important. Will our graduating student expect a better future in an industry with a greater margin of profit? I presume that a smaller, newer industry such as electronics or aviation might offer a technical man more reward than an older industry where the profit margin is less. Perhaps the industries with the high profit margins require them because of the uncertainty of the demand for their products, the dependence on government buying and other factors not present in the food industry. It is also apparent that the new or improved products which food technologists develop tend to have a greater profit margin than the older staples. There is apparently an adequate profit margin to permit the allocation of funds for product development and research.

THE JOB AHEAD

I am afraid the food industry is faced with very stiff competition in bidding for able young men. I do not feel pessimistic but I am sure there is a real job to be done to get the story of the opportunities and the worth of food technologists before the high school students selecting their college training, and the college students who are selecting a field in which to use their training. The wonderful scholarships which are being offered by industry through our Institute and other agencies are a substantial indication of industry's appreciation of the problem. However, each of us has found a rewarding challenge in our work and accomplishments and there could be no more effective recruiting device than telling our own stories and telling them widely.

STATE COLLEGE OF WASHINGTON OPENS NEW FOOD TECHNOLOGY CURRICULUM

A Food Technology program is being offered at the State College of Washington to provide graduate training for students wishing to enter this important field of science. The Staff is composed of regular staff members of five "participating departments," namely Animal Husbandry, Dairy Science, Horticulture, Foods and Nutrition (College of Home Economics), and Poultry Science.

Specific course requirements for advanced degrees in Food Technology are limited, in order to allow for maximum flexibility in individual graduate programs. General requirements for the M.S. include microbiology of foods, dairy bacteriology, biochemistry, and freezing preservation. General requirements for the Ph.D. candidates will include those for the M.S. plus additional appropriate course work, normally not more than 20 semester hours in any one department. Minors may be taken in such fields as Chemistry, Bacteriology, Botany, Zoology, etc., or in an engineering or an economics field.

Students may choose their research and thesis work in any "participating department." Graduate assistantships are available, and prospective Food Technology majors are invited to apply for them. Further information concerning research and thesis work, and graduate assistantships should be addressed to the Chairman of one of the participating departments listed above, or to the Dean of The Graduate School.

Annual Meeting Bulletin Board

June 10-14,1956, is some months away, but in St. Louis behind-the-scenes activity in preparation for the Sixteenth Annual Meeting of the Institute of Food Technologists is already under way. Dr. R. J. Sumner, chairman of the Program Committee, has issued the first call for papers (August issue) and has tentatively scheduled fifteen sessions and one symposium.

Five sessions will be centered on problems relating to methods of preserving or processing; namely, dehydration, fermentation, radiation, canning, and freezing. Sessions on commodity groups—citrus products, cereals, meat, fruit and vegetables—will accommodate papers in this area of food research and technology. Problems in engineering and related fields will be presented in three sessions—food engineering, packaging, and new

(Continued on page 10)

at long last...

an **IMITATION RASPBERRY**

with right-off-the-bush flavor!

GIVAUDAN'S NEW IMITATION RASPBERRY FLAVOR is an achievement long desired throughout the flavor-using industries.

Developed with painstaking care through many years of research, it duplicates with all of its fugitive and delicate nuances the rich flavor of the ripe raspberry as it comes fresh from the bush!

This new Givaudan development provides you with an opportunity to enhance—with true economy—the appeal of your raspberry-flavored products. Its high concentration and proved stability make it ideal for virtually every type of product in which raspberry is a popular flavor. We invite your inquiries.

Givaudan Flavors Inc.

330 West 42nd Street, New York 36, N. Y.

Branches: Philadelphia • Boston • Cincinnati • Detroit
Chicago • Atlanta • Seattle • Los Angeles • Toronto

ANNUAL MEETING BULLETIN BOARD

(Continued from page 8)

products and practices. Microbiological studies will be the technical concern of another session, and sensory testing, a standard feature of IFT annual meetings, will come in for treatment at one, and possibly two sessions. A general session for papers that do not clearly fit the sessions just described will be held.

In recognition of the fiftieth anniversary of the Food and Drug Law a slate of invited papers is being prepared. The Federal Food and Drugs Act of June 30, 1906, popularly known as the Wiley Pure Food Law because of the part that Dr. Harvey W. Wiley played in its enactment and enforcement, had a long and interesting history. The old law was replaced by a new one, the Food, Drug, and Cosmetic Act, which became fully effective January 1, 1940. The history of food and drug legislation is a rich field for scholars, but it is also full of human interest. Both aspects will be treated in the St. Louis Food and Drug Law Symposium—the *Proceedings* of which should become a key reference in the annals of "Wiley's Pure Food Law" and subsequent legislation.

Deadlines for 1956 Meeting Papers. January 1, 1956, is the deadline for titles for the 1956 meeting. February 1, 1956, is the deadline for abstracts. A standardized form for abstracts will be provided to all prospective authors. Send your titles and abstracts to Dr. R. J. Sumner, Chairman of the Program Committee, c/o Central Research Department, Anheuser-Busch, Inc., St. Louis 18, Missouri.

Annual meeting papers become the property of IFT (Section 4, 41, *By-Laws*) unless released by the Editor.

Informal Discussion Groups. Facilities will be available for informal sessions on topics of technical interest to a small group. Anyone wishing to organize a discussion group of this type is asked to inform Dr. Sumner at once so that the room and time may be scheduled.

Site of the Meetings. Meetings will be held in the Jefferson Hotel, St. Louis, Missouri.

PERSONNEL

DR. MATTHEW E. HIGHLANDS, food technologist for the Maine Agricultural Experiment Station at the University of Maine, has been named head of the Station's new department of food processing. Food Processing work by Dr. Highlands and his staff has previously been carried on as part of the activities of the Station's chemistry department. Expansion of the food processing industries of Maine in the last few years has far outgrown the facilities available to Dr. Highlands and his staff. In order to keep up with this industrial growth, the new department has been organized.

Among candidates for advanced degrees at Oregon State College in June was B. R. SURI, who took his doctor of philosophy degree in food technology. His dissertation was on chemical and physical changes in isolated beef muscle tenderized by infusion with sodium chloride.

Books

OUTLINES OF ENZYME CHEMISTRY. J. B. Neilands and Paul K. Stumpf, 315 pages. John Wiley & Sons, Inc., New York, 1955.

The purpose of this book, as stated by the authors, (a) "to introduce senior undergraduate and beginning graduate students to the general subject of enzyme chemistry, and (b) to provide background material for research workers in fields other than enzymology" has been most admirably achieved. In this reviewer's opinion, one of the most important assets of the book is its reference material. A few historical references are given, but in general the end of each chapter contains the latest references in the particular phase of enzymes research being discussed, along with the latest review articles for more detailed discussions of each subject.

The book is divided into four parts, bringing together the different physical and chemical principles of enzyme chemistry in such a manner as to give them greatest clarity in regard to their use in enzyme chemistry.

Part 1 deals with general principles of biochemistry, such as equilibria and ionization, isolation methods, criteria of purity, and characterization. Each subject is briefly discussed with emphasis placed on its application to enzyme research.

Part 2 covers the physical chemistry principles necessary for the study of enzymes. Brief reviews of reaction rates, oxidation-reduction, and energetics are presented. The effect of substrate concentration, temperature, and hydrogen-ion concentration on enzyme activity is discussed along with the action of inhibitors. The method of study of enzyme-substrate compounds is given and several specific examples illustrate how the existence of such compounds have been proved. The final chapter of Part 2 points out the specificity of enzyme action.

The first chapter of Part 3 is called "Classifications of Coenzymes" and, although many are briefly mentioned, the authors chose to discuss two main groups. The hydrogen transporting coenzymes, pyridine nucleotides, flavin nucleotides, and a recent addition to this group, thioctic acid are described. This is followed by the group of coenzymes responsible for the transport of phosphate. A very brief classification of enzymes is also presented in Part 3, followed by a more detailed discussion of the respiratory enzymes, their description, and action.

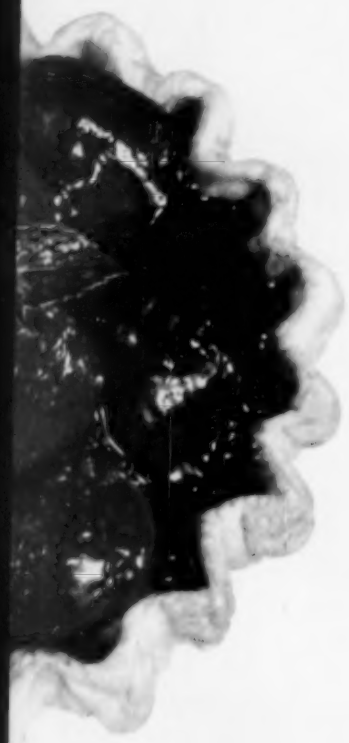
The final part of the book deals with metabolic patterns. The authors bring together the latest information and give a good description of glycolysis, tricarboxylic acid cycle, oxidative phosphorylation and fatty acid oxidation. The book ends with an interesting chapter on the synthesis of enzymes, written by Roger Y. Stanier.

Besides those for whom the authors intended this book, it is also highly recommended for anyone interested in a good review of the principles of enzyme chemistry and of the latest information dealing with the enzymes of metabolism.

ROBERT B. KOCH
Broadview, Illinois

248 calories if sw

This month,



If you are not counting calories, you don't need this new, non-fattening sweetener. If you are, you do.

You can save

eetened with sugar

MILLIONS OF DIET-SHOPPERS

September sees Sucaryl advertising go national . . . in full-color spreads and pages in Life Magazine, plus This Week, Parade and independent supplements —appearing in 91 major Sunday newspapers.

Now, millions more diet-shoppers will know about Sucaryl, and how it tastes just like sugar.

They'll be looking for it on the label of low-calorie foods. And you can

e a lot of calories

S LEARN ABOUT SUCARYL!

give them a Sucaryl-sweetened line without having to change your manufacturing processes.

We'll supply the Sucaryl free for a trial run. Just tell us whether you prefer Sucaryl Sodium or Sucaryl Calcium. Write to: Chemical Sales Division, Abbott Laboratories, North Chicago, Illinois.

248 calories if sweetened with sugar

148 calories if sweetened with non-caloric Sucaryl

Abbott Laboratories' new non-fattening sweetener —Sucaryl—opens up a whole new world of eating and drinking enjoyment to the millions who must watch their weight.

This is improved Sucaryl: A harmless substance without food value . . . without calories . . . but with the property of tasting just like sugar, and giving a sugar-like sweetness to drinks and foods. Sucaryl completely satisfies your craving for sweets when you're on a restricted, low-calorie diet. In normal daily use, improved Sucaryl sweetens without a trace of bitterness or aftertaste.

You can use Sucaryl everywhere: Use it in your morning coffee, on cereal or grapefruit. Use it in any and all cooking recipes that call for a sweetener. Foods prepared with Sucaryl can be baked, boiled or frozen without losing true, sugar-like sweetness. The only thing to remember is that the proper proportion to use varies with each recipe. So be sure to send for your free copy of the Sucaryl recipe book offered below.

You don't need Sucaryl if you don't have to worry about calories or carbohydrates. Sugar is one of the most highly concentrated sources of quickly available energy, and should be retained in normal diets. Sucaryl is intended for use in controlled diets. If you are in doubt about dieting, ask your doctor for proper guidance.

Look for the name Sucaryl on the label of prepared foods or beverages. It means that you can enjoy that low-calorie food or drink without adjusting your taste one whit.

If you are diagnosed as overweight or a diabetic, Sucaryl opens the way

If you are not counting calories, you don't need this new, non-fattening sweetener. If you are, you do.

You can save a lot of calories by sweetening with Sucaryl

...and you can't taste the difference

to greater eating pleasure. You can now enjoy a more normal variety of foods and beverages, and still follow the rigid requirements of your diet.

STRAWBERRY TARTS (Makes 8 tarts)

1 cup sifted, enriched flour	Cold water	2 tablespoons SUCARYL
½ teaspoon salt	1 quart strawberries	Solution or 48 tablets
⅓ cup shortening	(hulled)	3 tablespoons water

Mix and sift flour and salt; cut in shortening. Sprinkle with 1 tablespoon cold water; mix in lightly with fork. Add water until pastry gathers around fork in soft ball. Roll out ⅛-inch thick on lightly floured board, cut 8 rounds. Press pastry circles on inverted, fluted pastry pans; trim edges. Prick pastry with fork; bake upside down in hot oven (450°F.) 12 minutes. Cool slightly, remove from pans. Cool thoroughly. Crush slightly, 2 cups strawberries; add SUCARYL and 3 tablespoons water; simmer 5 minutes; cool; drain off liquid and save. Place cooked strawberries in tart shells. Fill with remaining whole berries. Spoon liquid over berries.

Get your free copy of Abbott's "Calorie-Saving Recipes" at your drug store. It's a brand new edition with dozens of kitchen-tested ideas. Or simply write: Sucaryl, Abbott Laboratories, North Chicago, Illinois. In Canada: Abbott Laboratories, Ltd., 1350 Cote de Liesse Road, Montreal, Quebec.

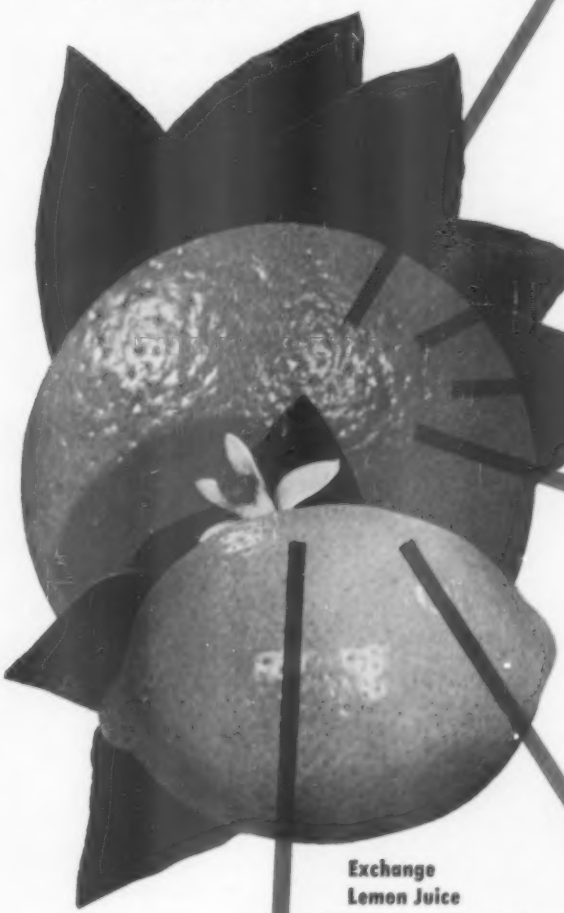
Sucaryl®

THE NEW, NON-FATTENING SWEETENER THAT TASTES JUST LIKE SUGAR

Available at your drug store in Tablet, Powder or Liquid form. For low-salt diets, ask for Sucaryl Calcium.

Look to Sunkist
for progressive research in food processing

Yes, in every field of food processing, the Sunkist Growers laboratories are making ever-widening contributions to the increased quality of food products. Here are some typical Exchange Brand product developments.



Exchange Oil of Orange

Always consistent, always outstanding in flavor, strength and aroma. An essence you can rely on. Made from fruit grown in the famous Sunkist groves of California.

Exchange Oil of Lemon

The 4-to-1 favorite over all other lemon oils combined! The reason is the superior flavor that comes only from California-grown lemons processed by exacting Sunkist standards.

Exchange Preserver's Pectin

Here is *even* jell strength that gives you consistent, complete reliability in setting control.

Exchange Low Methoxyl Pectin

A natural fruit pectin that jells without sugar. Completely tasteless, permitting the use of the most delicate flavors. Pies made with Exchange Low Methoxyl Pectin won't "run" or "weep" when cut—and you have never tasted such natural juicy fruit flavor. Famous too for aspics, jellied fruit or vegetable salads, dietetic preserves or non-sugar jells.

Exchange Lemon Juice

Nothing can match lemon juice for bringing out the natural flavor of *any* food product. It's a superior acidulant in the preparation of mayonnaise, fruit cocktail, figs, fruit nectar, prunes and other heavy-syrup products. Highly effective as an anti-oxidant in processing frozen foods. Citric acid molecules have also been established as effective in the retarding of mold growth. Available in concentrated or single strength form.

Sunkist Growers

Exchange ®

PRODUCTS DEPARTMENT • ONTARIO, CALIFORNIA
400 West Madison Street, Chicago 6, Illinois
99 Hudson Street, New York 13, N. Y.
318 Cedar Street, Dallas 2, Texas

Recently Elected Members of IFT

Kenneth D. Aalseth
5417 Lee Ave.
Downers Grove, Ill.

Georgia M. Amick
201 Gwynn Hall
Missouri University
Columbia, Mo.

Howard J. Anderson
3326 Hickory St.
Omaha, Nebr.

Dr. Dwight L. Baker
Froedtert Malt Corp. Res. Dept.
P. O. Box 712
Milwaukee 1, Wis.

James G. Bowie
Pacific Preserving Co.
2837 S. Fairfax Ave.
Los Angeles 16, Calif.

Rita Campbell
National Live Stock & Meat Bd.
407 S. Dearborn St.
Chicago 5, Ill.

Sidney A. Carlson
California Packing Corp.
P. O. Box 149
Honolulu 10, Hawaii

Evelyn J. Ceder
32 Keswick Road
Rochester 9, N. Y.

LeRoy Clardy
Swift & Co., Res. Labs.
Union Stock Yards
Chicago 9, Ill.

John Compton
John Labatt Ltd.
150 Simcoe St.
London, Ont., Canada

R. F. Conway
4901 Midmoor Rd.
Madison 4, Wis.

Major Iain W. Cullen, R.A.S.C.
35 St. Pauls Road
Weston-Super-Mare
Somerset, England

Dr. J. J. Denton
130 W. Maple Ave.
Bound Brook, N. J.

John A. Driver
Box 149
Honolulu, Hawaii

Erwin Earl
P. O. Box 2535
Kaaawa Farm, Ltd.
Honolulu, Hawaii

George F. Foy
Shulton, Inc., R. No. 46
Clifton, N. J.

Leon Ganford
Flavaroma Laboratories, Inc.
6245 Cottage Grove Ave.
Chicago 37, Ill.

Ernest Glaser
5962 W. Midway Park
Chicago 44, Ill.

John M. Gorton
1533 Grange Ave.
Racine, Wis.

James L. Guard
Jewel Food Stores
3617 S. Ashland Ave.
Chicago 9, Ill.

Dr. Ralph M. Heinicke
Hawaiian Pineapple Co.
P. O. Box 3380
Honolulu 1, Hawaii

J. J. Holzman
Aloha Papaya Co.
Honolulu Inter. Aairport
Honolulu, Hawaii

George P. Howard
Antoine Schnerr Co., Ltd.
122 S. Beretania St.
Honolulu 13, Hawaii

Sidney Kahan
66 Peachtree Lane
Roslyn Heights, N. Y.

Felix E. Kashbaum
830 Gannon St.
Madison, Wis.

Stanley W. Kasper
Weirton Steel Co. Qual. Cont.
Weirton, W .Va.

Eymard J. Keal
5025 Alrose Ave.
Memphis 17, Tenn.

P. de Lange
Central Inst. for Nutr. Res. T.N.O.
Catharijnesingel 61
Utrecht, The Netherlands

Anthony F. Legun
4841 Idaho Ave. No.
Minneapolis 22, Minn.

Stanley W. Lyttle
3 Curtis St.
Fulton, N. Y.

Dr. Elizabeth Mackay
Cornell University
Dept. of Food & Nutrition
Ithaca, N. Y.

Alan J. Malone
Taubmans Industries Ltd.
Mary Street
St. Peters, Sydney, N.S.W., Australia

William P. Mann
van Ameringen-Haebler, Inc.
201 N. Wells St.
Chicago 6, Ill.

DeWitt McCloskey
88 Kaiholu Place
Lanikai, Oahu, Hawaii

Robert G. Moench
R. G. Moench & Co., Inc.
11 Park Place
New York 7, N. Y.

Dr. Charles E. Mumaw
Hawaiian Pineapple Co.
P. O. Box 3380
Honolulu 1, Hawaii

Keng Chock Ng
Ohio State Univ.—Hort. Dept.
Food Processing Div.
Columbus, Ohio

William F. Nye, Jr.
65 Ohio Ave.
West Springfield, Mass.

E. Paul Orsay
van Ameringen-Haebler, Inc.
201 N. Wells St.
Chicago 6, Ill.

Jo. Parks
659 Peachtree St. N.E.
Atlanta, Ga.

Dr. John H. Payne
Experiment Sta., H.S.P.A.
Honolulu 14, Hawaii

Gordon L. Pickering
California Packing Corp.
P. O. Box 149
Honolulu, Hawaii

Donald A. Raffell
15 Tait St., Fivedock
Sydney, N.S.W., Australia

Eleanor E. Ragon
Foods & Nutrition Dept.
Michigan State College
East Lansing, Mich.

Robert L. Reddish
B-8-D College View
College Station, Tex.

Dwight E. Reed
353 Marshall Ave.
Bellwood, Ill.

Khizar H. Siddiqi
c/o Ghulam Hussain, B.A., LL.B.
Pleader
Civil Bazaar, Campbellpur
Punjab, West Pakistan

Reba Staggs
1100 No. Dearborn St.
Chicago 10, Ill.

Margaret J. Tims
School of Home Econ.
Oregon State College
Corvallis, Ore.

Verner Toldby
122 College Street
Buffalo 1, N. Y.

Dr. Austin C. Wagenknecht
Dept. Food Science & Tech.
N.Y.S. Agric. Expt. Sta.
Geneva, N. Y.

Edward K. Wardrip
Clinton Foods Inc.
Clinton, Iowa

Miles J. Willard, Jr.
125 Tyson Ave.
Glenside, Pa.

George Wright
Dept. Industry & Natural Resources
Charlottetown, P.E.I. Canada

Dr. Oscar C. Zoebisch
2119 Kaloa Way
Honolulu 14, Hawaii

STUDENTS

Lester Feller
102 Willard Way
Ithaca, N. Y.

Richard P. Ferrick
100 Ridgewood Rd.
Ithaca, N. Y.

Jean R. Geisman
144 E. 13th Ave.
Columbus 10, Ohio

Lewis Klotz
209 College Ave.
Ithaca, N. Y.

G. Robert Di Marco
Rutgers Univ. Plant Pathology
New Brunswick, N. J.

Asa O. Palmer
W. Danby Rd., R. D. No. 1
Newfield, N. Y.

William L. Seaton
663 N. High St., Apt. 41
Columbus, Ohio

Jack M. Sheneman
Dept. OS Micro. & Pub. Health
Michigan State Univ.
East Lansing, Mich.

Vance M. Wells, Jr.
High Street
Wilton, Maine

Selected Abstracts*

BIOLOGICAL SCIENCES

BIOCHEMISTRY

Nonenzymatic browning of foodstuffs. 1.
GORNHARDT, L. *Fette u. Seifen, 57,* 270-4 (1955).

A discussion of browning as it affects dried egg powder, dried milk products, meat and fish products, fruit and vegetables, bread, macaroni, sugar and starch syrup.

* These Selected Abstracts are made available to FOOD TECHNOLOGY through the cooperation of Dr. H. A. Campbell and the General Foods Corporation of White Plains, N. Y. The abbreviations found in these abstracts are similar to those used by Chemical Abstracts.

(Continued on page 14)

the greatest taste in chocolate

For all chocolate ingredients, Nestlé's is the first choice, known through the years for consistently fine quality.

PETER'S • RUNKEL'S NESTLE'S®

THE NESTLÉ COMPANY, INC.
2 WILLIAM STREET • WHITE PLAINS, N. Y.

WAREHOUSES:
Atlanta • Cambridge, Mass. • Chicago • Cincinnati • Cleveland • Dallas • Denver • Detroit • East Hartford, Conn. Fulton, N.Y.—Factory • Jacksonville • Kansas City, Mo. • Los Angeles • Milwaukee • Minneapolis • New Orleans New York • Philadelphia • Pittsburgh • Portland, Ore. • St. Louis • Salt Lake City • San Francisco • Seattle

®Trade Mark Reg.

SELECTED ABSTRACTS

(Continued from page 12)

Micromethod for determining the ring structure of sugars in nucleosides.

VISCONTINI, M., HOCH, D., AND KARRER, P. *Helv. Chim. Acta, 38,* 642-5 (1955) (in German).

The sugar chain is oxidized with periodic acid; the resulting dialdehyde is reduced with $NaBH_4$ and then hydrolyzed with HCl. The liberated alcs. can be analyzed by paper chromatography.

Influence of temperature and duration of heating on the acid hydrolysis of proteinaceous products. I. The dependence of cleavage of amino N on pressure and temperature.

HEINTZE, K. Z. *Lebensm.-Untersuch. u.-Forsch., 100,* 253-60 (1955).

Amino N values do not increase continuously with increasing pressure, but show several max. and min. indicative of destruction of some amino acids or peptides even at lower pressures.

Intrinsic viscosity and optical rotation of proteins in acid media.

YANG, J. T., AND FOSTER, J. F. *J. Am. Chem. Soc., 77,* 2374-8 (1955).

Bovine plasma albumin is subject to gross, reversible structural alterations upon reduction of the pH of its solns. Ovalbumin does not show this structural versatility. A preliminary survey was made of the behavior of ten addnl. proteins under similar conditions.

The degradation of collagen. II. The solubilization process in the acid pH range.

VEIS, A., AND COHEN, J. *J. Am. Chem. Soc., 77,* 2364-8 (1955).

The data support the view that intact collagen may be composed of a series of related proteins of not quite identical compn. The initial phases of the collagen-sol. collagen (gelatin) transition appear to take place with a very limited amt. of peptide bond hydrolysis.

Hydrolysis of amylotriose by crystalline salivary amylase.

PAZUR, J. H., AND BUDOVICH, T. *Science, 121,* 702-3 (1955).

Cryst. salivary amylase has been shown to produce hydrolysis of amylotriose and of 1-C^{14}-amylotriose to glucose and maltose using paper chromatographic technics. The comparative radioactivity of the products indicates a faster rate of hydrolysis for the glucosidic bond nearest the reducing end of the amylotriose.

An assay method for lipoxidase in animal tissue.

BOYD, D. H. J., AND ADAMS, G. A. *Can. J. Biochem. Physiol., 33,* 191-8 (1955).

An assay for lipoxidase in animal tissues has been developed eliminating the interference of heme compds. The procedure was suggested by the findings that cyanide inhibits heme activity and that potassium cyanide has no inhibiting effect on lipoxidase activity.

The effect of fat level of the diet on general nutrition. XV. Comparison of the protective effect of linoleic acid and linolenic acid against multiple sublethal doses of x-irradiation in the rat.

CHENG, A. L. S., GRAHAM, T. M., ALFIN-SLATTER, R. B., AND DEUEL, H. J. *J. Nutrition, 55,* 647-53 (1955).

The ability of linoleic acid to protect animals against x-irradiation injury has again been confirmed. Linolenic acid exhibits only a slight and insignificant protective effect against x-irradiation in male rats as judged by av. survival time and by the extent of mortality at the termination of the expt. However, when linolenate is administered at a min. level (10 mg.) together with a min. level of linoleate (10 mg.), a marked increase in protective action against x-irradiation is obtained which suggests that a synergism exists.

An apparatus for measurement of activity in small animals.

CASTANERA, T. J., KIMELDORF, D. J., AND JONES, D. C. *J. Lab. Clin. Med., 45,* 825-32 (1955).

A spring-suspended, stabilized cage and an integrator, made of modified clock parts, yields a cumulative, numerical index of the animal's activity. An automatic watering system for use with the unit is described and an instrument for calibrating the unit has been devised.

BOTANY

Quercetin glycosides of Grimes Golden apple skin.

SIEGELMAN, H. W. *J. Biol. Chem., 213,* 647-54 (1955).

A procedure for the paper chromatographic sepn. and identification of a mixt. of quercetin and quercetin glycosides is described. Hyperin (quercetin 3-galactoside), isoquercitrin (quercetin 3-glucoside), avicularin (quercetin 3-arabinoside), quercitrin (quercetin 3-rhamnoside), rutin (quercetin 3-rutinoside), and the hitherto unreported quercetin 3-xyloside were identified from the skin of Grimes Golden apples.

Formation of fatty acids in oleaginous seeds.

HILDITCH, T. P. *Oleagineux, 10,* 83-8 (1955) (in French).

The results of this study show that in vegetable fats the satd. and unsatd. fatty acids are produced by independent mechanisms.

Recovery and utilization of tree extractives.

ANDERSON, A. B. *Econ. Bot., 9,* 108-40 (1955).

A thorough review of extractives which may be obtained from trees and suggestions as to how their recovery may be exploited for com. use. 58 references.

Alkaloid hunting.

WILLAMAN, J. J., AND SCHUBERT, B. G. *Econ. Bot., 9,* 141-50 (1955).

As a guide in further search for alkaloids, their presence in and absence from some 250 families of plants are here tabulated. 32 references.

The isolation of plant cuticle with pectic enzymes.

ORGELL, W. H. *Plant Physiol., 30,* 78-80 (1955).

A simple and rapid method is described, involving the decompn. of leaf segments in solns. of commercially available pectic enzymes under certain conditions of pH, concn., and temp.

MICROBIOLOGY

Studies on spore germination. I. Effect of nitrogen sources on spore germination.

HACHISUKA, Y., ASANO, N., KATO, N., OKAJIMA, M., KITAORI, M., AND KUNO, T. *J. Bacteriol., 69,* 399-406 (1955).

From the present work it is clear that some amino acids stimulate germination in the presence of glucose and inorg. phosphate. There is no identity between the N requirements of the germination and those of the vegetative growth. Possible explanations of these phenomena are discussed.

Studies on spore germination. II. Effect of caramels from sugars and other carbon sources on spore germination.

HACHISUKA, Y., KATO, N., ASANO, N., AND KUNO, T. *J. Bacteriol., 69,* 407-12 (1955).

Almost all spores of *Bacillus subtilis* (PCI 219) begin to germinate in a short time when they are inoculated in phosphate buffer media contg. caramel made from glucose, and L-asparagine, DL-isoleucine, DL-valine, or DL-serine separately. Caramels of fructose, maltose, lactose, and sucrose have almost the same effect as caramel of glucose. The effect of these caramels cannot be completely displaced by the intact sugars and some fatty acids belonging to the tricarboxylic acid cycle. The significance of caramels on spore germination has not yet been decided, but they seem not to be used as an energy source for the development of the first phase of spore germination.

The problem of false coliform counts on fruit ice cream.

BARBER, F. W., AND FRAM, H. *J. Milk and Food Technol., 18,* 88-90 (1955).

A survey of the literature and plant data indicated that in the testing of ice cream for coliform organisms, fruit ice cream frequently showed coliform counts in excess of 10 per g. Numerous investigators have recognized that the ingredients added to ice cream—especially fruits, nuts, and flavors may be a source of coliform contamination. Preliminary studies showed that there are organisms present in banana, peach, and strawberry ice cream which give false pos. coliform tests.

Changes in bacterial counts and flavor of dry milk recombination by various means and storage at low temperatures.

(Continued on page 16)

The Taste of Success in CATSUP is an individual matter!

Some like it tart, some sweet . . . some like it spicy, some smooth . . . and still others request any one of the myriad shades of differences and combinations in between! Sectional preferences play an important part, and whatever type of product is manufactured . . . the processor must assure his customers of the same previously accepted flavor, pack after pack. To do this, he must have a seasoning that is first individually tailored to his specific requirements, and second, stabilized at this standard and kept constantly uniform at all times. D&O can provide such seasonings . . . in either water-soluble (SPICEOLATE) or dry-soluble (SPISORAMA) form, whichever is most convenient to your operation. Formulations can be varied to meet any manufacturer requirement . . . and the services of the Product Development Labs are available for individual testing. Consult D&O.

WRITE FOR SPICEOLATE AND SPISORAMA BROCHURES

Essentially for You

OUR 156th YEAR OF SERVICE

DODGE & OLCOTT, INC.

180 Varick Street, New York 14, N. Y.

Sales Offices in Principal Cities

ESSENTIAL OILS • AROMATIC CHEMICALS • PERFUME BASES • FLAVOR BASES • DRY SOLUBLE SEASONINGS

SELECTED ABSTRACTS

(Continued from page 14)

OLSON, J. C., AND NIELSEN, A. J. *J. Dairy Sci., 38,* 361-70 (1955).

Bacterial count of H_2O used for reconstitution varied widely between samples but did not increase to sufficient nos. to affect flavor of milk stored at 45 or 50° F. for 72 hrs. In the home the sanitary condition of kitchen utensils was found to limit keeping quality of milk more than type and temp. of H_2O used.

The effect of the initial cell concentration upon survival of bacteria at —22° C.

MAJOR, C. P., MCDOUGAL, J. D., AND HARRISON, A. P. *J. Bacteriol., 69,* 244-9 (1955).

Eleven species of bacteria were stored in broth at various cell concns. at —22° C. When the test organism occurred as single cells, plotting logs of survivors vs. the storage interval always gave survival curves of the same general form. Initially, the negative slope of the curves is steep, representing rapid destruction of the cells, but with each increment of time the slope decreases, representing slower and slower rates of death until after a few days or weeks the slope becomes negligible.

Bacteriological problems in translating from small equipment to the industrial scale.

EMERY, W. B. *Chemistry & Industry,* 236-40 (1955).

Discussed are inoculum—its type and method prepn., prepn. of the main fermentation medium, sterilization, temp. control during fermentation, aeration and agitation conditions.

Efficiency of cooling practices in preventing growth of micrococci.

MILLER, W. A., AND SMULL, M. L. *J. Am. Dietet. Assoc., 31,* 469-73 (1955).

This investigation was carried out to demonstrate the dangers accompanying slow and inadequate cooling of cooked foods stored in thick layers and subjected to various cooling methods, and to correlate the rates and degree of cooling with multiplication of "food poisoning" micrococci.

NUTRITION

Utilization of a "synthetic" triglyceride preparation by weanling rats.

MENG, H. C., AND YOUMANS, J. B. *J. Nutrition, 55,* 527-41 (1955).

The nutritional value of a synthetic triglyceride prepn. composed of oleic acid, 60.0; palmitic acid, 30.0; stearic acid, 7.4; and linoleic acid, 2.6% was studied using weanling male rats of the Sprague-Dawley strain as exptl. subjects. It was found that the synthetic triglyceride prepn. incorporated in the diet at 5 and 25% levels was biologically utilized in the body, using wt. gain, food intake and N and H_2O balances as criteria. The av. daily gain in wt. was 2.49 g. per rat for the fat-free group whereas rats fed 5% and 25% lard, 5% synthetic triglyceride, and 25% triglyceride diets gained 3.18, 3.45, 2.91, and 3.27 g. per rat per day, resp.

Observations on the production of smooth-surface rat caries by diets containing skimmilk and whey powders.

MCCLURE, F. J., AND FOLK, J. E. *J. Nutrition, 55,* 589-99 (1955).

Rats fed diets in which the protein was supplied in the form of 3 different skimmilk powders, developed smooth-surface caries which occurred predominantly on lower buccal areas. Diets contg. spray-process and roller-process powders were both much more cariogenic than a diet contg. a lypholized milk powder. The most severe cariogenicity was assocd. with the diet contg. a roller-process powder. These results support previous evidence that com. heat-processing of skimmilk powders may be an aggravating factor of the cariogenic effects shown by diets contg. skimmilk powders.

The nutritive value of fish proteins.

MILLER, D. S. *Chemistry & Industry,* 501 (1955).

Changes in the nutritive value occurring during processing are reported in this paper presented at a meeting of the food group of the Soc. Chem. Ind.

Effect of long time feeding of whole milk diets to white rats.

SPERLING, G., LOVELACE, F., BARNES, L. L., SMITH, C. A. H., SAXTON, J. A., AND MCCAY, C. M. *J. Nutrition, 55,* 399-414 (1955).

Results are given of rat feeding tests with whole milk and whole milk with a no. of additives. Reproduction and longevity studies are included.

The role of glycine in chick nutrition.

FISHER, H., SCOTT, H. M., AND JOHNSON, B. C. *J. Nutrition, 55,* 415-30 (1955).

The effect of 4% glycine supplementation to diets low in niacin and vitamin B_{12} was studied. It significantly improved feed utilization, a phenomenon which decreased with advancing age of the birds. The glycine requirement for optimum growth and feed utilization of fast-growing birds is in excess of 1.5% both in purified as well as practical starting rations.

Protein digestibility.

Nutrition Revs., 13, 156-7 (1955).

Evidence offered that digestibility is not a characteristic of an individual protein but rather is dependent upon the diet with which it is fed.

Histidine, an essential nutrient for growth of pigs.

EGGERT, R. G., MAYNARD, L. A., SHEFFY, B. E., AND WILLIAMS, H. H. *J. Animal Sci., 14,* 556-61 (1955).

Young pigs receiving a semi-synthetic diet contg. all 10 of the amino acids known to be required for the growth of the weanling rat failed to grow at a satisfactory rate. When histidine was added to their diets, the pigs showed increased appetites and resumed growth almost immediately. It was concluded that histidine is required for normal growth of young pigs.

Nutritional needs of older people.

STARE, F. J., AND SHEA, J. *Merck Report, 64,* 7-9, April, 1955.

Proper nutrition is of fundamental importance for the health and well-being of the older person. A diet high in protein, vitamins, and minerals is advisable. Such a diet should provide cals. sufficient to maintain adequate wt. On the other hand excess wt. is a hazard to be avoided by careful cal. control.

The relation of age to fat absorption in adult women together with observations on concentration of serum cholesterol

GARCIA, P., RODERUCK, C., AND SWANSON, P. *J. Nutrition, 55,* 601-9 (1955).

The pattern of fat absorption changes with advancing age. The max. no. of chylomicrons appearing in the blood after a standard test meal increases with advancing age. The longer the period required to reach a peak count, the greater the no. of chylomicrons in the blood at the time.

Studies of acetate metabolism in the hereditary obesity-diabetes syndrome of mice utilizing C^{14} acetate.

PARSON, W., AND CRISPELL, K. R. *Metabolism, Clin. and Exptl., 4,* 227-30 (1955).

This study fails to verify the report of a partial block of acetate utilization in the hereditary obesity-diabetes syndrome in mice.

PHARMACOLOGY AND TOXICOLOGY

Antagonism of fresh fat to the toxicity of heated and aerated cottonseed oil.

KAUNITZ, H., SLANETZ, C. A., AND JOHNSON, R. E. *J. Nutrition, 55,* 577-87 (1955).

The inclusion in a rat diet of 15-20% of refined cottonseed oil, aerated and heated to 95° C. for 200-300 hrs., led to rapid loss of wt. and death within 3 wks. Addn. of fresh oil to the diet contg. the heated and aerated oil protected the animals against the toxicity. Only growth retardation persisted. When fresh cottonseed oil was fed by dropper instead of being included in the diet, its protective effect was only slight. Extra feeding of 25 mg. of DL-alpha-tocopherol acetate (and other fat-sol. factors) gave mild protection. Peroxides are probably not responsible for the toxic effect of the heated and aerated cottonseed oil; polymerization may be a better explanation.

Production of experimental lathyrism in the rat by two different beta-substituted ethylamines.

DASLER, W. *Proc. Soc. Exptl. Biol. Med., 88,* 196-9 (1955).

(Continued on page 18)

CONTAINS NO COUMARIN

STRONGER THAN VANILLIN

imitation vanilla bean flavor by Firmenich

the direct and authentic

copy achieved by original research

Vanilla Bean Flavor by Firmenich stems from the vanilla bean. By original research, its components and desirable characteristics have been isolated, identified, and synthesized. By patient and painstaking laboratory techniques, they have been reconstructed for you in a precise and potent flavor material with all the aromatic qualities of the original. Vanilla Bean Flavor by Firmenich comes to you as an economical replacement of pure vanilla extract, of pure vanillin, or to use in combination, in the manufacture of all products that you flavor with this most popular of flavors.

FIRMENICH INCORPORATED

250 WEST 18TH STREET • NEW YORK 11

CHICAGO OFFICE: 612 NORTH MICHIGAN AVE.

FIRMENICH OF CANADA, LIMITED, 348 WALLACE AVE. • TORONTO

LOS ANGELES, 908 SOUTH OXFORD AVENUE

GENEVA • PARIS • LONDON

SELECTED ABSTRACTS

(Continued from page 16)

Crystals which were isolated from sweet peas by a method which had previously yielded a toxic product were found to have the same i.r. absorption spectrum as synthetic β-amino-proprionitrile sulfate. Synthetic β-amino-propionitrile and β-mercaptoethylamine, when fed to rats as their hydrochlorides, both produced skeletal changes similar to those caused by sweet peas.

Chronic toxicity for rats of food treated with hydrogen cyanide.

HOWARD, J. W., AND HANZAL, R. F. *J. Agr. Food Chem., 3,* 325-9 (1955).

Food contg. 100 and 300 p.p.m. of HCN produced no signs of cyanide toxicity during a 2 yr. feeding period. At termination hematological values were within normal limits and neither gross nor microscopic examn. of tissues revealed evidence of pathology due to HCN feeding. Definite increases in thiocyanate concns. were found in the tissues of the exptl. animals.

Hemoglobin concentration, thyroid weight and growth rate in rats during minimum fluoride ingestion.

AUSKAPS, A. M., AND SHAW, J. H. *J. Nutrition, 55,* 611-21 (1955).

When F^- was administered in the drinking H_2O to rats as NaF at levels of 1, 5 and 20 p.p.m., there was normal growth and reproductivity, no depression of hemoglobin formation, no detectable F^- uptake by thyroid glands, no hypertrophic changes in the thyroid and no decrease in animal resistance to a severe respiratory infectious disease.

PHYSIOLOGY AND MEDICINE

Effect of chronic ethanol intoxication of liver lipid content of rats.

MALLOV, S. *Proc. Soc. Exptl. Biol. Med., 88,* 246 9 (1955).

Chronic alc. intoxication was produced in rats by tube feeding diets in which EtOH was isocalorically substituted for some of the carbohydrate in the control diet. Large supplements of the lipotropic vitamin B_{12} and choline, protected against this fatty infiltration of the liver.

Fat metabolism in three forms of experimental obesity. Fatty acid turnover.

BATES, M. W., MAYER, J., AND NAUSS, S. F. *Am. J. Physiol., 180,* 309-12 (1955).

The results of feeding C^{14} carboxy labeled palmitic acid indicate that different types of obesity are characterized by different patterns of fat metabolism.

Explanation of the effect of feeding desiccated thyroid on the incidence of dental caries in the rat.

RYAN, E. J., AND KIRKWOOD, S. *Science, 121,* 175 6 (1955).

It is suggested that the anticariogenic action of desiccated thyroid may result from an increased flow of saliva and/or increased concn. of salivary iodide. The cariogenic action of the antithyroid substances is the result of the reverse conditions.

Electrolyte disturbances in potassium deficiency.

Nutrition Revs., 13, 148-51 (1955).

The results of studies reviewed show that: K deficiency in rats produces a marked loss in muscle K concn. This is the primary source of the K that is lost from the body in that deficiency, although there is also a reduction in the concn. of K in the plasma. There are disturbances in kidney function in K deficient rats as shown by the reduction in plasma chlorides and the increase in bicarbonate.

Lowering of serum cholesterol by utraviolet irradiation.

ALTSCHUL, R. *Geriatrics, 10,* 208-12 (1955).

In cholesterol-fed rabbits, u.v. irradiation inhibits a rise in serum chlosterol and atheromatous lesions. Of 78 patients, mostly with vascular diseases, given single or multiple u.v. treatments, a significant no. showed a definite decrease in serum cholesterol. It is probable that this lowering of serum chlosterol may slow down the atherogenic process. In 16 out of 24 patients with hypertension, repeated irradiations were followed by a lowering of blood pressure.

The use of urinary deuterium oxide concentrations in a simple method for measuring total body water.

FALLER, I. L., BOND, E. E., PETTY, D., AND PASCALE, L. R. *J. Lab. Clin. Med., 45,* 759-64 (1955).

It was shown that D_2O administered orally, and intravenously in the same subject would measure the same values for total body water, and that identical concns. of D_2O could be obtained from corresponding urine and serum samples.

FOOD AND FOOD TECHNOLOGY

GELATIN

Molecular configuration of gelatin.

GOUINLOCK, E. V., FLORY, P. J., AND SCHERAGE, H. A. *J. Polymer. Sci., 16,* 383-95 (1955).

Intrinsic viscosities, light scattering turbidities and dissymmetries, and sedimentation consts. have been detd. for each of 2 high mol. wt. gelatin fractions in 1 *M* KCNS, pH 6.5, at 30°. It is concluded that the configurational character of the gelatin chain in aq. media is not much affected by its polar linkages or by intramol. H bonding.

LEGISLATION

Misbranded spaghetti.

Food, Drug, Cosmetic Law Repts., 158, 1-2, May 10, 1955.

A spaghetti product which has a protein content of about 20% is misbranded because it does not conform to the definition and standard of identity for spaghetti. The product cannot be considered as having a separate identity as far as complying with the food standards is concerned even though it had a separate identity for many years prior to their passage.

PRESERVATION

Surface studies on surface ripened cheese.

AECU 2957. *Nuclear Sci. Abstr., 9,* 63 (1955).

The feasibility of using radiation in safeguarding vacuum-packed cheese spreads was investigated. Data are presented from 16 expts. on soft surface-ripened cheese samples inoculated with *Clostridium botulinum* spores and irradiated at various dosages of Co^{60} γ radiation. Results from expts. designed to study the effect of irradiation on the toxin-producing ability of spores showed this characteristic was unaltered by sub-lethal dosages. Data are included from studies of the effects of medium, atm., and temp. on radioinactivation of *C. botulinum* toxin and spores in cheese.

SUGARS AND STARCHES

Application of compositional knowledge to beet sugar technology.

OWENS, H. S., STARK, J. B., GOODBAN, A. E., AND WALKER, H. G. *J. Agr. Food Chem., 3,* 350-3 (1955).

Investigations of the compn. of beets and their processing liquors have been under way for about 5 years. Results of these studies and their significance in beet technology are reviewed.

The quality of starch puddings containing whey and/or milk solids.

HANNING, F., DE GOUMOIS BLOCH, J., AND SIEMERS, L. L. *J. Home Econ., 47,* 107-9 (1955).

Although whey itself may have a pH of 5.8-6.0 there was no difference in the pH of puddings made entirely with nonfat milk solids (NFMS) or with 25% whey. The substitution of 25% whey for NFMS, on the whole, gave puddings of superior quality because of better flavor, appearance, tender delicate structure, and smooth consistency. This would have application, especially, in packaged pudding mixes that contain dried milk to which H_2O alone would be added.

RADIOCHEMICAL TECHNOLOGY

Atom blast frozen food tested.

Canning Trade, 77, 7, May 30, 1955.

Samples of frozen foods tested showed only nominal radiation and no appreciable change in color and flavor when stored in freezers in test area.

Radiation sterilization. Review of the literature in selected fields.

NP-5543. 74 pp. February, 1955; *Nuclear Sci. Abstr., 9,* 331 (1955).

(Continued on page 20)

Standardized pure dye strength

We standardize each National Certified Food Color in the exact strength that our 50-year experience has shown to give most satisfactory results.

Our Certified Colors are produced from basic raw materials wholly within our modern Buffalo Food Color plant. Each batch is held within remarkably close limits so that you, in turn, can standardize your color formulas.

Regardless of season or climate, or variations in the color of incoming foodstuffs, you can have uniformly-appetizing color in your finished goods if you always specify National Certified Food Colors.

Write for your copy of the informative National Certified Color Catalog giving helpful information on blends for popular food-color shades, suggestions on the preparation and care of stock solutions for various food products and other useful data. No cost or obligation.

Allied Chemical

CERTIFIED COLOR DIVISION

NATIONAL ANILINE DIVISION ALLIED CHEMICAL & DYE CORPORATION • 40 RECTOR ST., NEW YORK 6, N. Y.

Boston Charlotte Chicago Philadelphia Portland, Ore. San Francisco Toronto

SELECTED ABSTRACTS

(Continued from page 18)

Results are summarized from a literature survey of studies on subjects related to the radio induced sterilization of food. Topics discussed include the effects of ionizing radiation on proteins, lipids, carbohydrates, vitamins, enzymes, meats and the radiation sensitivity of spoilage microorganisms. 200 references.

The effect of gamma irradiation on storage life of potatoes.

SAWYER, R. L., AND DALLYN, S. L. *Am. Potato J., 32,* 141-3 (1955).

Irradiation of tubers with 10,000 r. and higher has completely controlled sprouting regardless of the storage temp. used.

STATISTICS

Comparative sensitivity of pair and triad flavor intensity difference tests.

HOPKINS, J. W., AND GRIDGEMAN, N. T. *Biometrics, 11,* 63-8 (1955).

Power curves are developed to illustrate that the "triangular" test is not the most efficient. The statistical advantage per aliquot of "triangles" appears to be more than offset by a greater discriminatory ability in "pair" tests.

Further contributions to the theory of paired comparisons.

KENDALL, M. G. *Biometrics, 11,* 43-62 (1955).

Several methods are outlined of ranking a no. of objects that are presented in pairs. Some suggestions are given for selecting a sub-set of all the possible pairs.

MISCELLANEOUS INFORMATION

A practical approach to analog computers.

STRONG, J. D. *Instruments, 28,* 602-10 (1955).

This article illustrates the compn., set up, and application of analog computers in simple enough form to permit the novice to visualize its means of operation and value.

A new job for chlorophyll.

Mfg. Chemist, 26, 94-5 (1955).

Chlorophyll coated paper prevents the tarnishing of Ag even in H_2S concns. of 80,000 times greater than found in air. The role of chlorophyll appears to be that of absorbing H_2S and the mechanism will be of interest to those who are trying to unravel the method of chlorophyll's deodorizing action.

PATENTS

Quick-cooking cereals.

KNOCH, H. Brit. 722,333, January 26, 1955.

Prepn. of a quick-cooking cereal or farinaceous food product, e.g. rice, tapioca, etc. The cereal is first soaked in water, below the gelatinization temp. of the starch in the cereal, till not more than 20-40% of the moisture has been absorbed, the substance is heated at 212-30° F. in the presence of H_2O or steam at a pressure 5-20 lbs./sq. in. above atm., to cause gelatinization of the starch, and the substance is then dried.

Coated solid particles.

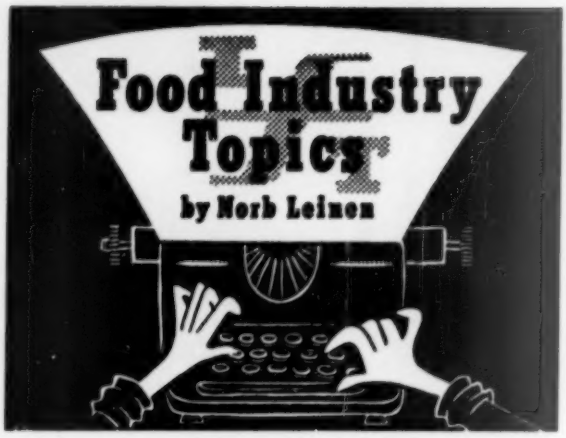
SOUL, D. C. Brit. 721,467, January 5, 1955.

Process for coating the surfaces of particles with a straight chain fatty acid having 12 or more C atoms in the mol., or with the interaction product of such an acid with the particle substance, to modify the phys. properties of the particles. A soln. of an NH_4 or volatile amine salt of the acid is mixed with the solid and the product dried at a temp. to decompose the salt.

Animal fat.

To British Glues & Chemicals, Ltd. Brit. 722,311, January 26, 1955.

A continuous process for recovering high quality fat in high yield from soft fat products, i.e. contg. no bones. The products, together with a liquid, are continuously fed to a container in which they are subjected to repeated intense impacts delivered through the medium of the liquid. The membranes of the fat-contg. cells are ruptured and fat is liberated without the products being reduced to cell size. The resulting mixt. is continuously removed from the container, and the fat is sepd. out of the mixt. by gravity or centrifugation.



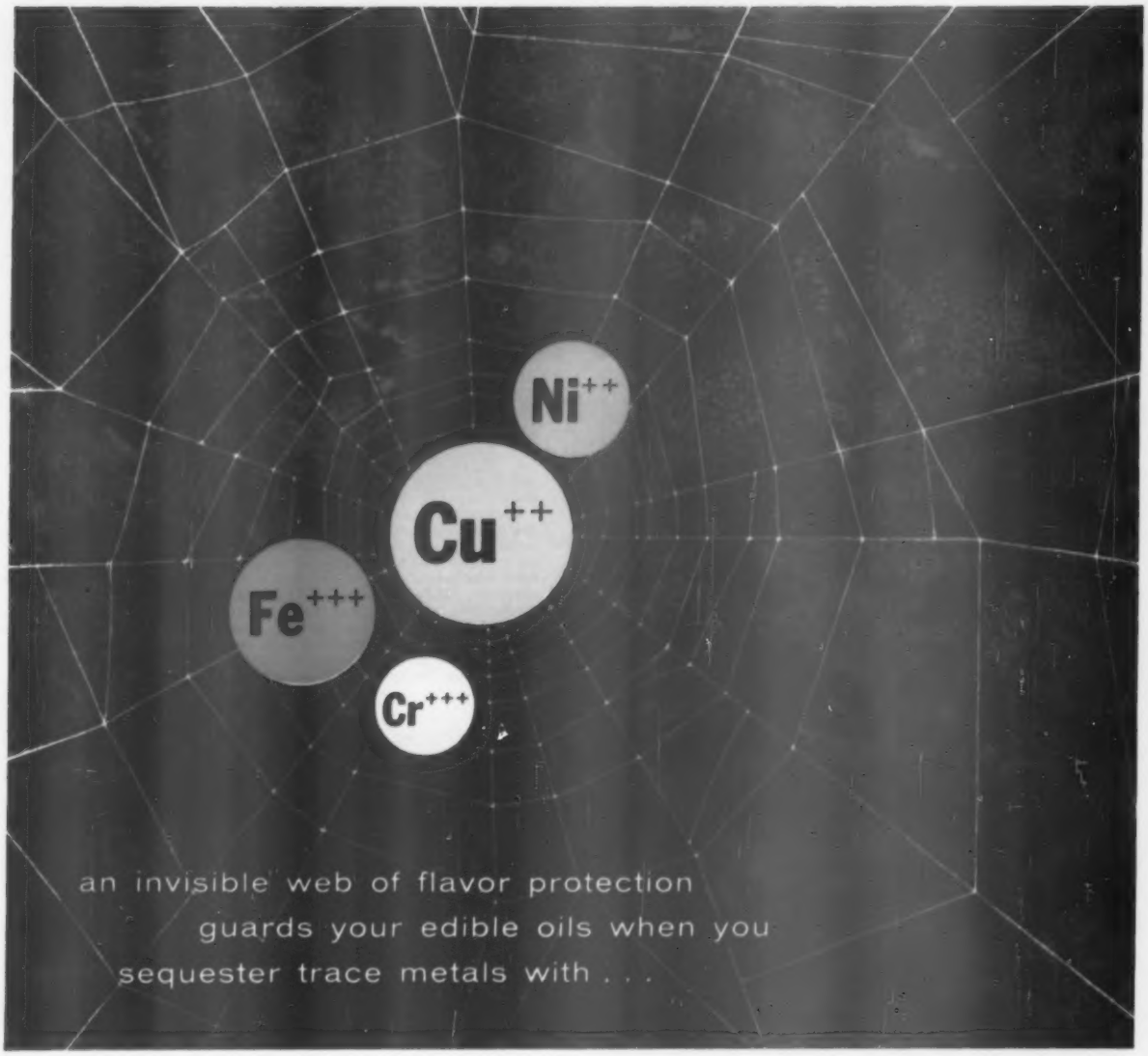
. . . *in the public interest*

"Readers who have no access to facts are conditioned to accept any statement about electronics or atomic energy," observes the June 15 *Information Bulletin,* published by The Refrigeration Research Foundation, 200 Midland Bldg., Colorado Springs, Colo. "We are almost in a state of science-psychosis in this country," it continues, "because scientific achievements of the first half of the 20th century have been fantastic. Let us remember, however, that this world is still finite and science is finite. In the overwhelming majority, scientists investigating food radiation are cautious about uninhibited prophecies because they know the facts. Let us remember that industrial adoption will have to wait until scientists get and interpret and integrate facts so that commercial implementation may then become technically and economically feasible." The *Bulletin* states the present consensus of U. S. scientific opinion is about as follows: "A limited number of food and drug items might be commercially radiated in a few years if the cost of such processing is feasible. Presently, pasteurization by radiation, plus refrigeration of the radiated products seems the most logical procedure. Sterilization of product presently causes undesirable change but further research may develop ways to avoid that. Public health clearance is not yet available, but will come perhaps in a few years because induced radiation problem does not seem to be serious. Engineering and economic problems are massive, and solution is distant and unpredictable in most cases because basic facts are not yet available." The Foundation will shortly issue a special bulletin dealing with the present status of food radiation, and has contacted about 50 research and industrial leaders concerned with foods and related fields to obtain their opinions.

◆ ◆ ◆

The sole remaining state barrier to the sale of SUCARYL-sweetened beverages was removed August 30—effective date of a newly enacted Ohio law permitting artificial sweeteners in diabetic beverages. The development climaxed a 4-year effort on the part

(Continued on page 22)



PFIZER CITRIC ACID

You can retard the development of off-flavors and off-colors in your hydrogenated oils easily and economically with Pfizer Citric Acid as your sequestering agent. It complexes metallic ions, so they can't oxidize unsaturated fatty acids. Find out—*in detail*—how Pfizer Citric can improve your product's stability and safeguard its sales appeal.

Write for Technical Bulletin 72.

Manufacturing Chemists for Over 100 Years

Pfizer

CHAS. PFIZER & CO., INC.
Chemical Sales Division
630 Flushing Ave., Brooklyn 6, N.Y.
Branch Offices: Chicago, Ill., San Francisco, Calif., Vernon, Calif., Atlanta, Ga.

FOOD INDUSTRY TOPICS

(Continued from page 20)

of Abbott Laboratories, North Chicago, Ill., to obtain equitable state laws on SUCARYL. At the outset, 33 states had laws or regulations prohibiting the use of SUCARYL (cyclamate, Abbott) in beverages. Now it may be sold in every state. Under the new Ohio law, labels of special dietary beverages flavored with SUCARYL or other non-caloric sweeteners must specify the sweetener used and indicate how much of the drink's total weight is sweetener.

This palatial villa, "Creux de Genthod," on the shores of Lake Geneva, served as the temporary "Little White House" of President Eisenhower during the recent Big Four talks at Geneva. It was loaned to the President by Mr. André Firmenich, chairman of the Board of Firmenich, Inc., New York City, and senior partner of Firmenich et Cie of Switzerland.

The National Fund for Medical Education, 2 W. 46th St., New York 36, N. Y., has produced its first documentary film, "Danger at the Source." Prepared as a public service by Fox Movietone, the 13½ minute, black and white, 16 mm. sound film tells the story of medical education in America. Ray Middleton, star of "Annie Get Your Gun" and "South Pacific," contributed the narration. Filmed in medical schools and teaching hospitals, and supervised by leading medical educators, "Danger at the Source" is available for group showings. The Fund was founded in 1949 to gain private support for the medical schools. It already has distributed nearly $7,000,000 in unrestricted grants to the 81 schools. The need—and the goal—is $10,000,000 annually.

. . . *things new under the sun*

A newly developed, non-toxic insecticide announced by Niagara Chemical Division of Food Machinery and Chemical Corp., Middleport, N. Y., should interest food processors and handlers in view of new insecticide residue tolerances established by Food and Drug Administration under provisions of the new Miller Bill. Niagara Pyrenone 606 Spray is an oil-free emulsifiable concentrate containing 60% piperonyl butoxide and 6% pyrethrum. When diluted with water, it can be used safely in all food handling areas. In addition to its effectiveness and non-toxic properties, its freedom from oil is an important feature in view of its use in food processing and canning, where oil based insecticides might be classed as adulterants. The product has been accepted by the U.S.D.A. for use in the food packing and canning industry.

Continental Can Company's new 9-ounce size Cap Sealed soft drink can is the same diameter as a standard 6-ounce or 7-ounce soft drink bottle, and closely approximates it in height. Because of its dimensions, 202 x 503, it may be run through present bottling equipment with minimum modifications, and is described as an ideal package for use in most automatic vending machines. It is possible also to merchandise the item in the same 6-pack carrier most bottlers now use for their returnable bottles. The 9-ounce can (center), along with Continental's 6-ounce can (left) and 12-ounce can (right), incorporates the firm's latest developments of an outside curl on top of the cone, eliminating any raw metal inside the can, and a spray wax coating lining the entire can interior.

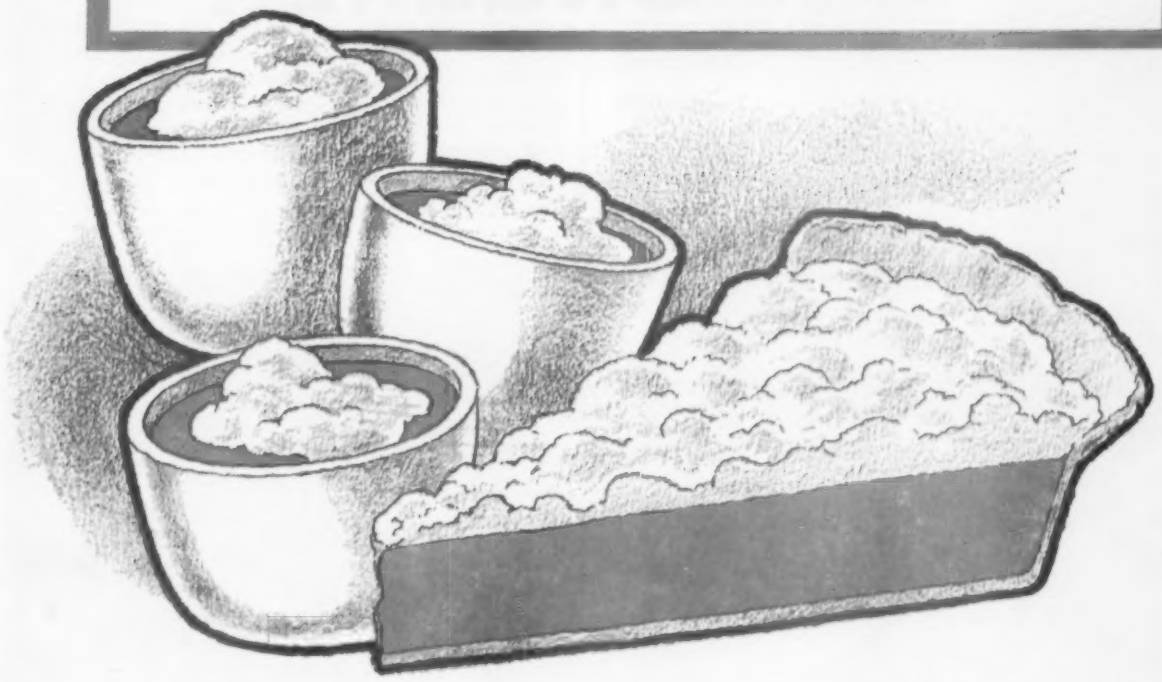
Free-flowing dry products may be packaged automatically in nesting type round containers with a new filler introduced by Anderson Bros. Mfg. Co., 1907 Kishwaukee St., Rockford, Ill. Stated to be the first machine of its type perfected for dry products, the Anderson Model 441 uses cup dispensing and capping equipment proved for many years in the packaging of ice cream, cottage cheese, and other products. Over 300 variations of the capper and dispenser are available, so that food processors may select from a wide range of cup sizes. Model 441 is ideal for products like dry beans, peanuts, bread crumbs, dry dog food, or any other free-flowing dry product.

Two coloring agents, Pfizer Vegetable Color and Pfizer Beta Carotene, are offered by Chas. Pfizer & Co., Inc., 630 Flushing Ave., Brooklyn 6, N. Y. Both products, which can be blended with vitamin A to specification, show a high degree of color uniformity and stability. Their use is seen ideal in imparting a natural yellow color to margarine, shortening, butter, bakery products, edible oils, and allied products. Both are available in bulk or in custom blends.

The chemical firm also announces that acetonedicarboxylic acid, a well known, highly reactive chemical, is available for the first time in pilot plant quantities. Designated as ADA, the compound is derived from fermentation-produced citric acid. A white crystalline powder of high purity, ADA is seen useful for preparation of pharmaceuticals, insecticides, disinfectants, fungicides, dyestuffs, chelating agents, amino acids, leavening agents, and as a synthetic intermediate. For information on above items, write the company's Chemical Sales Division at the above address.

(Continued on page 28)

FLAVORS for PUDDING POWDERS and PIE FILLERS



Why is today's housewife so enthusiastic about these popular corn starch pudding powders and pie fillers? For many good reasons: They are quick and easy to prepare, and they provide appetizing, nutritious, fine-textured, deliciously-flavored desserts at very low cost. All she has to do is add milk and water, stir or cook—a few minutes and her job is done.

The manufacturer's job of producing these products is easy, too —with the proper mixture of corn starch, sugar and vegetable gums, plus distinctive, rich, flavor-color combinations that require only simple mixing for uniform distribution throughout the powder base. Here are some of the special, long-shelf-life FRITZSCHE flavors that are helping to make new friends and new profits for dessert powder manufacturers everywhere:

OIL CHOCOLATE IMITATION #2
FRITZBRO BUTTERSCOTCH IMITATION #1
FRITZBRO LEMON CONCENTRATE
EKOMO VANILLA IMITATION
FRITZBRO COCONUT IMITATION #1 SPECIAL
FLAVOR COMPOUND #10538 CHERRY IMITATION
FLAVOR COMPOUND #10423 PEACH IMITATION
FLAVOR COMPOUND #10539 BANANA IMITATION
MODERN IMITATION FLAVOR BASE WILD STRAWBERRY
EKOMO RASPBERRY IMITATION
ESSENCE ALMOND
FRITZBRO AROME MAPLE IMITATION
OIL CUSTARD FLAVOR IMITATION
FRITZBRO COFFEE CONCENTRATE EXTRA
ESSENCE CARAMEL IMITATION #3

For test samples of these flavors, please address us on your letterhead specifying the flavors desired.

FRITZSCHE *Established* 1871 *Brothers, Inc.*

PORT AUTHORITY BUILDING, 76 NINTH AVENUE, NEW YORK 11, N. Y.

BRANCH OFFICES *and* °STOCKS: *Atlanta, Georgia, Boston, Massachusetts, °Chicago, Illinois, Cincinnati, Ohio, Cleveland, Ohio, °Los Angeles, California, Philadelphia, Pennsylvania, San Francisco, California, St. Louis, Missouri, °Toronto, Canada and °Mexico, D. F.* FACTORY: *Clifton, N. J.*

You're sure to be in

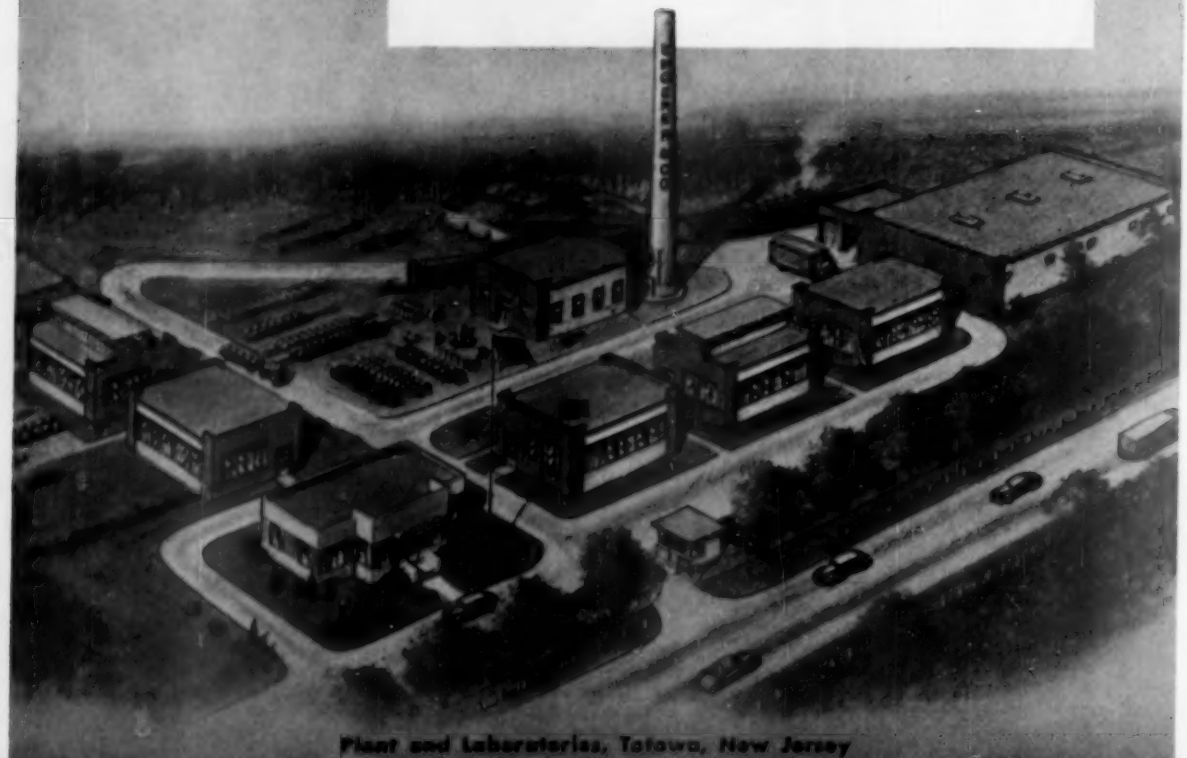
GOOD TASTE

when you specify

UNGERER

IMITATION RUM OIL JAMAICA No. 2974

Another top quality product of the Ungerer laboratories. Samples and technical information on the use of this flavor in your product will be supplied on request.



Plant and Laboratories, Totowa, New Jersey

Ungerer & Co.

161 Avenue of the Americas, New York 13, N. Y.

CHICAGO • BOSTON • PHILADELPHIA • ST. LOUIS • LOS ANGELES • ATLANTA

Utilization of Fruits in Food Products[a]

W. V. CRUESS
The University of California, Berkeley, California

THE BABCOCK-HART AWARD ADDRESS, 1955

The Stephen M. Babcock Award was established in 1948; in 1954 it became the Babcock-Hart Award, co-honoring Edwin Bret Hart, a colleague and contemporary of Dr. Babcock. As mentioned by Dr. Cameron *(5)* in his 1954 Award address, it is not difficult to understand why the Institute of Food Technologists and the Nutrition Foundation chose the names of these two great investigators and benefactors to identify this Award. One needs only to recall their very great achievements in biochemistry and nutrition.

For the benefit of those not familiar with the background aspects of the Award, a few words of explanation are in order. Each year a committee of IFT chooses a recipient[b] for the Award, which is sponsored by the Nutrition Foundation. The Nutrition Foundation sponsors three other similar awards; namely, to the Institute of Nutrition, to the American Dietetic Association, and to the American Medical Association. These three awards are granted on the basis of contributions to the advancement of clinical nutrition or to the furtherance of fundamental scientific knowledge in the field of nutrition, whereas the Babcock-Hart Award is given on the basis of scientific or technological contributions which lead directly to technological developments that promote or otherwise influence better nutrition. This last mentioned requirement guided the speaker in the selection of subject matter for the present paper.

When the committee and Dr. Glen King notified the speaker of his selection to receive the Award for 1955, it seemed next to impossible to choose an appropriate topic from among the varied investigations, past and present, of the Department of Food Technology of the University of California. However, consultation with several colleagues revealed a promising lead. It has long been our belief that if fruits could be made available in new and more attractive forms, especially as an integral part of such products as breakfast cereals, candies, soda waters, prepared pudding powders, prepared cake mixes and other "non-fruit" items, consumers would enjoy better eating and better health. Out of this, then, came the theme—utilization of fruits in food products to promote better foods and better health.

DIETARY VALUE OF FRUITS

Lack of space will prevent an extended discussion of the nutritive values of fruits and fruit products. The speaker *(8)* has reviewed this subject and furnished a selected bibliography in another paper. Many others have also covered this subject.

Certain fruits, notably citrus and guava, are rich sources of vitamin C; some are good to fair sources of thiamine, or riboflavin, or both; those rich in carotene, such as apricots, peaches, and prunes possess good to very good vitamin A potency. All fruits yield an "alkaline ash" when metabolized in the body and therefore tend to maintain or improve the alkaline reserve of the blood, Saywell *(49)* and Mrak *et al. (40)*. Most fruits exert a mild laxative effect if eaten in sufficient amounts.

Whipple *(58)* has reported that apricots, peaches, prunes, and apples—when fed at the rate of 200 g. per day per patient—markedly promoted hemoglobin regeneration in cases of simple or severe anemia. They are 35-40% as effective as liver in this respect. The data of Morgan, Perlman and Groody of this University *(38)* confirm Whipple's findings for prunes.

A very useful tabulation of the most important constituents of fruits, including vitamins and minerals is given in the H. J. Heinz Company's book "Nutritional Data" *(35)*. Cameron *(5)* has given an excellent and comprehensive review of the nutritive value of canned foods including fruits.

DEHYDRATION OF PRUNES

At one time, virtually all California dried prunes were sun dried, a fact that was emphasized in advertising the product. The rays of the sun were alleged to greatly improve "healthfulness" and eating quality. Although a few dehydrators were in existence in that day, they were used only in years of early fall rains. In such years it was necessary to save the rain soaked fruit from spoilage by applied heat. But the early dehydrators were usually inefficient and poorly designed.

Investigations were begun at the University of California in 1917 and during the ensuing ten or more years concentrated effort was made to improve dehydration technology, dehydrator design, and techniques of operation, Cruess and Christie *(21)*, Christie and Nichols *(6)*. As this work progressed, it was found—to the satisfaction of all concerned—that dehydration, when properly conducted, resulted in such marked improvement in quality that the dehydrated fruit was essentially a new product. As such, it warrants some discussion here.

It was found early in the course of these studies that the fruit has a critical temperature range—namely, 160-165° F. during the final stages of dehydration. At temperatures much above the critical, marked heat damage to color, flavor, and odor usually occurs. During the initial stages higher temperatures can be used because evaporative cooling occurs, and the temperature of the fruit is then below that of the heated air used for drying.

---

[a] Presented before the General Session, June 14, 1955, Fifteenth Annual Meeting of the Institute of Food Technologists, Columbus, Ohio.

[b] Previous winners of the Babcock (now Babcock-Hart) Award are: 1948, Dr. Fred C. Blanck; 1949, Mr. Clarence Birdseye; 1950, Dr. Carl E. Fellers; 1951, Dr. Samuel C. Prescott; 1952, Dr. Fred W. Tanner; 1953, Dr. Chas. N. Frey; and 1954, Dr. Edwin J. Cameron.

Not only did dehydration produce a dried product of very much better quality than sun drying but it usually gave a higher yield. Loss of sugars, which occurred by respiration during sun drying, was minimized in dehydration. The even heavier losses of sugar by yeast fermentation during foggy or rainy weather was also prevented. Table 1 gives typical data on this point, Cruess and Christie *(21)*.

A puzzling observation was the apparent increase in total sugar content in the dehydrated samples, as determined by the copper reduction method. Our surmise was that hydrolysis of a complex carbohydrate may have occurred during dehydration, resulting in liberation of reducing sugar.

Dehydration has practically replaced the sun drying of prunes in California, largely as a result of the research and industry service of this department. California now produces over 100,000 tons of dehydrated prunes annually.

SPANISH TYPE GREEN OLIVES

Turning to a consideration of other typical utilization projects of this laboratory, we shall give attention next to Spanish type green olives. The production of olives in the U. S. A. is confined, except for a very small area in Arizona, to California.

Until 30 years ago, practically all green olives used in the United States were imported from Spain. Vaughn *et al. (56)* report imports at about the level of 7,000,000 gallons and California production at 1,500,000 to 2,000,000 gallons, annually. The latter might be considered to be more or less a new product insofar as production in the United States was concerned at that time, 1920-25; therefore this type of olives comes within the scope of our discussion.

TABLE 1

Comparative yields of dried prunes by sun drying and dehydration [1]

	Product	Total weight [2]	Pits	Flesh	Sugar
		pounds	*pounds*	*pounds*	*pounds*
Experiment Number 1	Fresh	100	5	95	no data
	Sundried	42.4	5	37.4	18.9
	Dehydrated	49.0	5	44.0	20.4
Number 2	Fresh	100	5	95	15.4
	Sundried	29.5	5	24.5	11.8
	Dehydrated	37.5	5	32.5	15.8
Number 3	Fresh	100	5	95.0	19.6
	Sundried	37.2	5	32.0	18.7
	Dehydrated	40.2	5	35.2	20.8
Number 4	Fresh	100	5	95	24.1
	Sundried	47.2	5	42.2	23.8
	Dehydrated	51.4	5	46.4	24.9
Number 5	Fresh	100	4.9	95.1	21.2
	Sundried	43.3	4.9	38.4	20.4
	Dehydrated	44.8	5.3	39.5	20.3
Number 6	Fresh	100	5.5	94.5	17.5
	Sundried	35.0	5.0	30.0	16.3
	Dehydrated	38.7	5.0	32.7	17.5
Averages	Fresh	100	5.1	94.9	19.6
	Sundried	39.1	5.0	34.1	18.3
	Dehydrated	43.4	5.1	38.3	20.0

[1] These tabulations are taken from the California Agricultural Experiment Station *Bulletin 350*, 1926.

[2] Weights of the dried prunes are calculated to 20% moisture content.

In 1923-24 the speaker visited and studied the green olive establishment and olive groves in and around Seville, in Andalucia, Spain. We then attempted to produce Spanish type green olives in California by the methods used in the Seville district. Certain difficulties, however, were encountered, Cruess *(15)*. The process used in Spain consists in first treating the green olives with a dilute solution of sodium hydroxide to remove most of the bitterness, to modify the toughness of the skin, and to render the flesh more readily permeable to the lactic bacteria responsible for fermentation. Most of the hydroxide is then leached from the olives in cold water, an operation normally requiring 18-30 hours. The olives are then barreled in fairly strong brine and allowed to undergo lactic fermentation, during which the color changes from grass green to "olive green," the acidity increases to 0.5 to 1.5 g. per 100 c.c. as lactic and the characteristic texture and flavor develop.

Under California conditions there were problems to overcome. The cold temperatures of November to April arrested the fermentation in most cases. Other fermentations ceased because too little fermentable carbohydrate was present. In some cases the Queen or Sevillano variety developed large gas pockets or cleavage zones in the flesh. Often the color of the finished product was gray instead of olive green (really a yellow-green). In some cases "Zapatera" or a sage-like odor and flavor developed. In other cases the pickled olives were brownish red near the pit. Occasionally, blistering and softening of the flesh occurred. Film yeast and mold growth sometimes caused loss of acid and led to eventual spoiling of the olives in the barrels or butts.

It was found that if the olives in brine in jars were placed in a warm room, e.g., 70-75° F., fermentation continued normally—provided other necessary conditions were met such as sufficient fermentable material. In 1925 incubation of several hundred 50-gallon barrels of green olives in large artificially heated rooms was successfully accomplished and incubation has now become general practice for that portion of the pack that must be ready for the holiday and winter trade.

As mentioned, often the fermentation process ceased at low acidity, even under incubation. In studying this problem, determinations of total sugars and mannite were made on a considerable number of samples of the fresh olives, on samples where the NaOH had been leached out, and again after fermentation had "stuck" (ceased). Results showed a lack of fermentable material and possibly waste of some of the sugar by yeasts and other non-acid producers. Lack of sugar seemed to be the cause of many arrested fermentations. The following table gives some of the data on this point.

As lack of fermentable carbohydrate appeared to be one important cause of arrested lactic acid fermentation 1 to 2% of commercial dextrose was added to "stuck" lots of green olives. Fermentation resumed almost immediately and acid production became normal. The experiment was made in several plants. The data in the following table are typical.

Lots I and II were of very good quality. Lot III somewhat too low in acidity and lot IV very much too

TABLE 2
Changes in total sugar and mannite of green olives during preliminary treatment and fermentation [1]

Sample	Total sugar in flesh	Mannite in flesh	Sugar plus mannite	Content of flesh as lactic acid
	%	%	%	%
Sevillano olives, fresh	1.84	1.85	3.69	.83[2]
Sevillano, after leaching to remove lye	.37	.90	1.27	.05
Sevillano, after 3 months' fermentation	0	.15	.15	.45
Manzanillo olives, fresh	6.16	2.28	8.44	.68
Manzanillo olives, after leaching	1.86	1.12	2.98	.15
Manzanillo olives, after 3 months' fermentation	.14	.20	.34	.34
Average all samples, fresh	3.23	2.80	6.03	....
Average all samples, after leaching	1.00	1.08	2.08	....

[1] Cruess *(15)*.
[2] The acid in the fresh fruit is not lactic but for convenience is so expressed.

low. The olives in lot IV softened badly. Evidently dextrose was more suitable than lactose.

Olives contain considerable mannitol, which greatly decreases or disappears during fermentation. Some of it is probably converted to lactic acid during fermentation.

The optimum temperature range for acid production by several types of lactic bacteria found in olives was determined by Vaughn, Douglas and Gilliland *(56)* in this laboratory, to be about 30-37° C., or 86-98.6° F. In commercial incubation practice 75-80° F. is a common range.

Gray color of the skins of the fermented olives was found to be caused by too prolonged leaching in water after lye treatment or undue exposure to air between applications of water. This resulted in the oxidation of certain phenolic substances in the olives.

Cleavage of the flesh and gas pockets at the line of demarcation between the lye treatment and untreated flesh of Sevillano variety olives was found to be due to use of too strong a lye solution. The flesh of the California olives appeared more sensitive to the NaOH than of those grown near Seville. In Seville in 1923 a 2.5% NaOH was often used. In our California tests, this proved to be much too strong for Sevillano olives. At 1.5-1.60% results were very satisfactory.

Vaughn *(56)* of this staff has studied the bacterial aspects of green olive pickling extensively. The development of "zapatera" (sage-like) odor and flavor was found to occur only when the pH is above pH 4.3.

Occasionally, during the initial stages of fermentation, gaseous decomposition with blister and fissure formation occur. Vaughn, Douglas and Gilliland *(56)* state that this decomposition is due to coliform bacteria, usually *A. aerogenes* and *A. cloacae*. Use of strong initial brines, acidification of the brine, and addition of starters of lactic bacteria are measures used to inhibit the activity of the coliform organisms. As Alvarez *(1)*, Tracy *(55)* and others have shown, coliform bacteria are also responsible for spoilage during the pickling of ripe olives. Growth of butyric acid anaerobes with development of a butyric odor occasionally occurs if the pH is too high and if the salt content of the brine is too low.

Red color of the flesh surrounding the pits was found to be due to the use of a susceptible variety such as the Barouni, or to insufficient treatment with dilute NaOH.

TABLE 3
Effect of addition of dextrose on "stuck" fermentations of Manzanillo olives [1]

Lot	Container	Acid as lactic g./cc. April 27	Acid as lactic g./100 cc. Oct. 15
I	25 gal. barrel; 2% dextrose added April 27	0.42	0.95
II	5 gal. barrel; 1% dextrose added	0.25	0.60
III	5 gal. barrel; 1% lactose added	0.15	0.35
IV	5 gal. barrel; no addition	0.20	0.18

[1] Cruess *(15)*.

FROZEN PRODUCTS

The tremendous expansion of the frozen fruit and vegetable industry is of comparatively recent origin. When the work of our laboratory in this field was begun in 1917 frozen fruits were not available in grocery stores, although some were frozen in 50-gallon barrels for the preserving, baking, and ice cream industries.

In 1917 Overholser, Bjarnasson and the writer *(46)* undertook investigations on the processing, packaging, and freezing storage of fruits for retail distribution. Our belief was that they might be stored in wholesale amounts in central freezing warehouses and distributed by ice cream stands, using ice cream cabinets to hold the frozen fruits packed in small containers. We favored tin containers. It was found that a syrup pack was preferable to a dry sugar pack for sliced fruits, and that a tightly sealed air tight container such as a tin can greatly retarded oxidation. As frozen food cabinets became available in stores, the industry developed rapidly in the late 1920's and early 1930's. Some of our research was then put into practice.

Frozen orange concentrate has become the most important of all frozen fruit products, a development that has occurred within the space of a very few years. We congratulate the Florida Citrus Commission, other research agencies in Florida, and Florida and California concentrate producers for initiating and developing this phenomenally successful product.

We believe that frozen prune concentrate made by concentrating a water extract of dried prunes at low temperature and very high vacuum, as is done with orange concentrate for freezing, has great commercial potential for use on the breakfast table or as a "night cap" when diluted 3 + 1 with water, Cruess *(14)*. The product is convenient to store and use and is much superior to the usual canned or bottled juice in flavor. We find that one precaution is necessary in its production; the prune juice (extract) must be treated with a pectolytic enzyme before concentration, to prevent jellying of the concentrate.

Our department was the first, we believe, to investigate and advocate the freezing of lemon syrups and concentrates for making lemonade. Cruess, Seagrave-Smith and Glazewski *(30)*. Marsh of this department assisted the first freezer of lemon concentrates and syrups to get under way commercially.

CARBONATED BEVERAGES

A great portion of the carbonated beverages with fruity names contain very little or no fruit, a situation that is primarily due to the extremely lively competition in the beverage industry. It is also a fact that fruit drinks, unfortunately, require pasteurization, or addition of preservative to prevent spoilage.

We have long been of the opinion that it is perfectly feasible to supply the American public with carbonated beverages (soda water) containing 25% or more of fruit juice. Our investigations, Cruess and Irish *(23)*, showed that by using pure fruit syrups and concentrates, blending with the usual plain sugar syrups, adding the blends to soda water bottles, adding carbonated water to fill, sealing with crown caps and pasteurizing at 140° F., excellent and healthful carbonated fruit drinks could be made readily.

We made a sales trial during a 3-year period and found that consumers would willingly pay a price of 2 bottles for 15c. We also packed and sold similar beverages that were not carbonated. Demand in Berkeley, California, was excellent for both types. One large company in California packs a line of bottled, still, diluted and sweetened fruit juice drinks that are very popular in the West. No doubt most members of the audience have used one or more of them.

Perhaps with the use of tin containers which are easily pasteurized, fruit soda waters, both still and carbonated, may come into yet greater use.

NEW NUT PRODUCTS

California is the only state that grows almonds on a large scale and it is also much the largest producer of walnuts. At present these nuts are used in the home in various ways and by commercial processors in candies and bakery products chiefly. Experimentally, Cruess *(13)*, we have processed them in special forms such as smoked, toasted, in powder form with dextrose or sucrose as a base for macaroons, or treated as whole or halved meats with various antioxidants to prevent rancidification. We have also prepared them in several other forms.

Although the sugar retards rancidification of the powdered-sugar-nut-mix it does not permanently prevent it. If packed in vacuum or nitrogen in sealed air tight cans or jars, all of these products keep indefinitely. Their retail sale would be facilitated, however, if they were packed in plastic bags. That calls for use of an antioxidant.

Musco and Cruess *(42)*, found that B. H. A. or Eastmans' Tenox II greatly extended the shelf life of the nut pieces or the various processed products mentioned above. NDGA, Cruess and Armstrong *(20)*, was fairly effective but in the concentration required tended to impart a slightly bitter taste. Light hastened rancidification. Moisture content proved to be a very critical factor. In general the lower the H_2O level the better was the keeping quality. At 5% moisture content rancidification was much more rapid than that at 4% in walnut meats in halves.

Formation of free fatty acid in walnut meats appeared to be catalysed by a naturally occurring enzyme.

In another study a small diet squad ate a fairly large weighed quantity of walnuts for several days in addition to the regular meals. After a rest period of several days the same amount per day of walnut meats was eaten with candy. In both tests a considerable laxative effect was noted. Where no candy was used the panel members experienced considerable digestive discomfort. When candy was included with the nuts no digestive discomfort was experienced and the panel members' "appetite for walnuts" was maintained. Without the candy they became "very tired of walnuts." All of this is not new, but it confirms the well known principle that "oils and fats burn more brightly in the body in the presence of carbohydrates." The lesson appears to be that we should serve nut meats with raisins, or other dried fruits, or with candy or sugar in other forms.

RIPE OLIVES

While ripe olives are pickled and used in all olive producing regions of the world, the American style canned ripe olive is packed only in California and to a very limited extent in Arizona. It was first preserved by heat in sealed containers (glass jars), by Professor F. T. Bioletti *(3)* of this University in 1901 and at about the same time by Mrs. Freda Ehmann, a commercial packer. A temperature range of 190° F. to 212° F. was used.

This finding was soon adopted by other packers and extended to the use of tin cans as well as glass jars. As a new product in the early 1900's it merits consideration.

In the early 1920's spoilage by a spore-bearing anaerobe caused serious loss. K. F. Meyer of this University, J. R. Esty *(32)* of the National Canners Association, and Burke *(4)* of Stanford University and their associates studied the spoilage organism very thoroughly and established a safe processing temperature and time, namely, 240° F. for 60 minutes for the canned product.

Unfortunately, when this severe cook was put into practice, the canned olives as then pickled softened badly, or developed a scorched or soapy taste. Our investigations showed that two conditions favored these undesirable changes; namely, inadequate treatment with NaOH or insufficient leaching of the NaOH from the olives before canning. By suitable modification of the pickling process, Cruess *(10)*, the canned olives withstood the new cook satisfactorily.

Also during that earlier period, 1920-1925, bacterial spoilage during leaching of the lye treated olives in water was very common and losses were heavy. We found that the spoilage could be arrested or prevented by pasteurization of the olives at this stage in water at 175-180° F., Cruess and Guthier *(22)*. This treatment was devised in 1922 and was soon adopted generally in all plants in which the spoilage had been occurring. As previously mentioned, Alvarez *(1)*, Tracy *(55)* and Vaughn *(56)* and associates have made a very complete study of this type of spoilage and the responsible organisms, usually of the aerobacter group. The spoilage is now well controlled.

In the earlier years of the ripe olive industry, plain tin cans were used as containers but after a few months' storage the color of the olives usually bleached to an

unattractive brown or yellow color, in contrast to the black color at time of canning. Our research in 1919, Cruess *(12)*, indicated that the reducing action of the plain tin plate caused the loss of color but that use of enamel lined cans prevented it. Such cans were adopted universally by canners. Color loss is not a problem in glass containers. Color is, however, greatly affected by the pH value of the fruit at time of canning, Cruess *(9, 10)*.

About 6 years ago we canned sliced ripe olives experimentally, both plain and smoked. Most olive canners are now commercially packing the plain sliced, and one concern is canning both types.

USE OF FRUITS IN CANDY

For many years our department has conducted experiments on the use of fruits in various forms in commercial as well as in home candy formulas, Cruess *(11)*, O'Neill and Cruess *(45)*, Cruess *(18)* and Binder *(2)*.

Recently one of the largest producers of candy bars has placed a raisin and coconut bar on the market and now distributes it throughout the Midwest and East. Several other producers also include some raisins in candy bars or chocolate coat raisins. In time, perhaps, the use of fruits in commercial candies will increase. We find that dried figs, raisins, dried apricots and prunes are satisfactory in various candies. Fruit candies do not satiate the appetite as quickly as do other candies.

FRUITED CEREALS

H. M. Reed *(48)*, of this department, published in 1929 early experiments on the preparation of ready-to-serve cereals containing fruit, particularly dried prunes.

Others have extended Reed's experiments, the most recent publication being that of Musco *(41)* on flaked and shredded cereals containing up to 50% of dried fruit. More recently flakes and shreds containing 75% of dried fruits have been made experimentally. The ready-to-serve cereals containing sieved or ground fruits tend to be hygroscopic, although similar to fruitless cereals in this respect. Data published by Musco illustrate this point. (See Table 4.)

One large cereal company is packing raisins with its quick cooking rolled oats. The product keeps well and the raisins become plump and meaty during the short cooking period recommended on the label.

THE DARKENING PROBLEM

On prolonged storage at room temperature or above, concentrated or dried fruit products, such as dried fruits in various forms, jellies, preserves, and concentrates darken in color. The change is not due merely to oxidation as it will occur in the absence of oxygen. Apparently furfural and perhaps other aldehydes formed in deterioration of sugars are involved in the darkening reactions. The problem as it concerns dried fruits and fruit juice concentrates has been studied in this department extensively by E. R. Stadtman *et al. (51, 52)*, F. H. Stadtman *(53)*, Mackinney and Temmer *(37)*, Haas *et al. (34)*, Wahab *(57)*, Natarajan and Mackinney *(44)* and Joslyn and Marsh *(36)*. It is still unsolved and must be taken into account in the storage of fruit products of low H_2O content.

TABLE 4

Moisture absorption by fruited and plain cereals stored in open containers for 10 days

Cereal	Moisture uptake
	%
(1) Fig flakes	4.55
(2) Prune flakes	4.79
(3) Apricot flakes	4.27
(4) Wheaties [2] (no fruit)	3.43
(5) Sugar crisp [2] (no fruit)	4.62

[1] Musco (1953).
[2] Commercial products.

"FLOR" WINES

Most consumers of table wines believe that use of dry wines with the meal enhances the pleasure of eating and aids digestion.

Research on wines has been conducted at this University since 1880, or for about 75 years with 15 years out for the Prohibition era.

As wine was made by the ancients it is not a new product and would in general not be suitable for the present paper.

However, until relatively recently the so-called *flor* Spanish process sherries were not made in America and therefore could be termed a new product insofar as production in the U. S. A. is concerned. The procedure and the special yeasts used in making such sherries were introduced into California by the writer *(7)*, ably assisted by Dr. L. A. Hohl Strohmaier, R. H. Vaughn and several graduate students during the past 20 years.

Several wineries are now producing these sherries in California, chiefly for blending with "regular" California sherries in order to improve their bouquet and flavor.

In brief, in the *flor* sherry procedure as used in California, certain film yeasts originating in Spain are grown continuously on unfortified dry white wine in oak butts or barrels, or in small redwood tanks. At intervals of 12 to 6 months, part of the wine is drawn off, fortified with neutral high proof brandy, and aged for several years in oak butts, or barrels, before blending and bottling. In Spain a somewhat more complex, the so-called "solera," system is used.

We found that most of the *flor* yeasts from Jerez de la Frontera in Spain and similar yeasts from the Arbois (Chateau Chalón) district of France possessed remarkable alcohol forming power and alcohol tolerance. Unlike their close relative, the ordinary wine yeast *Saccharomyces ellipsoideus*, they have the power not only to ferment sugary liquids but also that of forming heavy films on wines containing up to 16.5% alcohol. They produce a pungent bouquet and flavor in the wine.

Table 5 illustrates the alcohol forming power of several of the pure cultures when used to ferment grape juice.

The optimum range for film growth was about 65-75° F. or about 18° C. to 24° C.; growth was very scanty at 85° F. (29.4° C.), and at 50° F. (10° C.).

Aldehyde production characterizes the film stage, and this compound undoubtedly contributes much to the

TABLE 5

Alcohol forming power of flor yeasts in grape must [1]

Yeast	Alcohol percent by volume by normal fermentation	Alcohol percent by volume, syruped fermentation
Jerez yeast No. 2	17.5	18.4
Jerez yeast No. 3	16.0	17.6
Jerez yeast No. 4	18.0	19.1
Jerez yeast No. 5	17.5	19.0
Jerez yeast No. 6	18.0	18.8
Arbois yeast No. 10	17.7	18.8
Arbois yeast No. 13	17.4	18.4

[1] From Bull. 710, Univ. Calif. Agr. Expt. Station.

flavor and bouquet. In a typical experiment several of the cultures during 3 months' incubation increased the aldehyde content of the base wine from an initial of 11 p.p.m. to 100 to 153 p.p.m.

The increase in volatile esters during several months incubation of wine with the film was slight.

The effect on the volatile acidity, chiefly acetic, is however very marked. In several winery scale and laboratory experiments the film reduced the volatile acidity to very low values of wines that were originally too vinegar sour to be potable.

The effect of a number of vitamins and growth substances on film growth was determined by Freiberg *(33)*. Yeast extracts, ammonium salts, urea, asparagine, glutamic acid, peptone and several other nitrogen sources had a marked stimulative effect. Thiamine, biotin, glycerol, phosphates, sugars, folic acid, and several other substances had little to no effect. Ascorbic acid and riboflavin had a noticeable inhibitory effect. Urea or ammonium sulfate appeared to be the most practicable addition for wines that fail to support a vigorous growth of the film.

NEW CANNED FRUIT PRODUCTS

Canned California fruits are available in relatively few forms. If additional packs were on the grocers' shelves to add variety perhaps consumers would use more canned fruit and be benefited thereby.

One such new product is julienne style cling peaches or pears, canned in medium syrup for use in salads, pies, puddings, etc., Cruess, O'Neal and Rivera *(29)*. Practical procedures have been devised and used on a small commercial scale in canneries. Consumer response to the experimental packs was good.

Similarly there should be a potential demand for canned sauces made from cling peaches, apricots, pears, or figs for use as a breakfast dish, or in ice cream, puddings, open face pies, toppings, etc. Such products have been packed experimentally in our department and in a cannery. At one time we placed a small pack on the Berkeley market, and found it popular, Cruess *et al. (29)*.

Fruit juices fortified with pectin or pectin and citric acid were canned experimentally and tested by housewives for making jelly, Cruess and Marsh *(26)*. These products take the labor and "mess" out of home jelly making.

Sieved fruits in canned form also appear to have possibilities for use in ice cream, sherbets, puddings, etc. and can be prepared and canned with practically no hand labor, Cruess and Marsh *(26)*.

FRUITS WITH DRY READY MIX PREPARATIONS

There are available to modern housewives many instant or quick-cooking dry mixes for puddings, cakes, cookies, and other dishes.

We find that raisins or chopped vacuum re-dried fruits can be used in such dry mix preparations and are especially successful in cooky mixes and pudding mixes. Such mixtures were stored without noticeable deterioration for more than a year at 80-85° F., Cruess and Musco *(28)*.

FRUIT NECTARS

In 1933 a graduate student who hailed from Damascus was much interested in making a canned juice from apricots.

He found that when the apricots were first steamed to soften them and to destroy oxidizing enzymes, pureed in a tomato pulper, sieved in a tomato finisher, and the resulting puree mixed with an equal volume of dilute sucrose syrup and canned, an attractive beverage of good keeping quality resulted. [See Shallah and Cruess *(50)*].

Shortly thereafter the commercial canning of such a beverage, called apricot nectar, became successful. Other fruit nectars followed in due course. Fruit nectars are now an important pack.

Apricots give a basic ash, are rich in carotene, are a fair source of vitamin C and several of the B vitamins.

HIGH MOISTURE DRIED FRUITS

As packed for retail sale, dried fruits contain less than 24% of moisture and owing to loss of moisture on the grocers' shelves they often reach the consumer at much lower moisture content. Even at 24% moisture content they are somewhat too "heavy" in consistency to be eaten out of hand readily.

If, however, the moisture content is increased to 30-33% and maintained in that range either by sterilizing the fruit by heat in hermetically sealed containers as recommended by Mrak and Cruess *(39)* or by sterilizing with an organic epoxide in moisture proof plastic bags as recommended by Phaff, Mrak and Whelton *(47)* of this department, the products are of excellent texture and flavor for eating out of hand. They also cook quickly.

Dried figs and prunes are now packed commercially by the latter method and are increasing rapidly in popularity.

CANNED FRUIT COCKTAIL

A product that was new in 1920—namely, canned fruit cocktail—was originated by this department during fruit canning experiments in a commercial cannery in Lincoln, California, Cruess *(7)*. The experimental pack was sold in Berkeley in order to test consumer reaction. It consisted of diced clingstone peaches, pears and pineapple, and grapefruit. Later a similar product was packed commercially by a cannery near San Jose, California; its production rapidly spread to other canneries. The pack has now increased to 8-9,000,000 cases

per year and provides consumers with an attractive dessert or fruit mix for use in gelatin desserts, puddings, salads, etc.

OTHER PRODUCTS

There is need for a stable non-hygroscopic dry fruit product in small pieces for use in baked products and confectionery. In 1929 J. H. Irish, P. H. Richert and the speaker *(24)* found that by grinding and regrinding a mixture of dried fruit with two to three times its weight of commercial dextrose, heating and extruding the mixture, or screening it to give pieces about the size of peas and drying to bone dryness a granular product that was not hygroscopic and which possessed excellent keeping qualities could be made. The granules can be ground and sifted to give a powder. Similar mixtures of fruit concentrate and dextrose gave water soluble granules or powders.

Another line of products that have been studied in the department is that of canned or frozen sieved fruits or purees, for use in ice creams, milkshakes, sherbets, ices, open face pies, sauces, jams, etc., Cruess and Marsh *(27)*. These are not baby foods, although they may be so used. Some apricot puree is canned commercially. Sieved cooked dry prunes were found to be a product well adapted to use in bread, cakes, cookies, candies, ice cream and in other ways by Mrak and Cruess *(39)*.

Until recently the housewife could not purchase canned fruits prepared for use in pies. Sliced canned apples and several other prepared fruit mixes, designed for use in the home as pie fillings have appeared on the market recently. This department has given considerable attention to experimental canned pie fillings, particularly those made of raisins, cling peaches, or apricots, or pears [Cruess *(7)* and Cruess and Musco *(28)*].

Recently Strachan and associates *(54)* in British Columbia have made a thorough study of preparing and canning such products.

A FINAL WORD

The department of Food Technology of the University of California has devoted considerable research and development work to the utilization of fruits in new ways and in new products with the purpose of providing consumers with additional and more attractive food products. It has been hoped that through such new and improved uses consumers would eat more fruit with corresponding benefit to health. Examples of such uses have been covered in this paper. This field of endeavor has been carried on simultaneously with the department's "regular" research program on other problems of the processing and storage of fruit and vegetable products.

Acknowledgments

During my more than 40 years of University service, I have derived the greatest satisfaction in watching our former students advance in their profession in many countries of the world. They are scattered from Pakistan to Quebec, and from California to Argentina. One is now a member of India's Parliament, another is dean of the College of Agriculture in Cairo, others are heads of departments of food technology in the U. S. A. and abroad; many are in industrial positions, ranging from production manager in a large canning organization to a bench chemist, a recent graduate. Several are now grandfathers; others are new graduates. From time to time we hear from most of them. We are greatly interested in them and take pride in their progress. Some have tarried a while in graduate research and the results of their studies have formed an important part of the department's achievements. Their research and their participation in industrial processing and preservation of food products have had a very important effect in improving consumer nutrition in the U. S. A. and abroad.

I wish also to express my appreciation of and deep satisfaction in the research, teaching, and public service achievements of the members of our department's staff, past and present. They joined us as young, inexperienced men, for the most part, but over the years have become seasoned veterans. This paper has drawn heavily on their investigations. They are a fine group and I wish them the best of luck for the future.

LITERATURE CITED

1. Alvarez, R. S. A causative factor of floaters during curing of olives. *J. Bact.*, **12**, 359-365 (1926).
2. Binder, Roy. Raisins for new candy ideas. *Manufacturing Confectioner*, **34** (April, 1954).
3. Bioletti, F. T. Olive cultivation, oil making, pickling, diseases. *Bull. 123*, revised, Univ. of Calif. Agr. Expt. Sta. (1901).
4. Burke, Georgina S. Studies of thermal death time of spores of *Clostridium botulinum*. *J. Intect. Dis.*, **33** (4) 274-284 (1923).
5. Cameron, E. J. The canning industry nutrition program. *Food Technol.*, **8**, 586-592 (1954).
6. Christie, A. W., and Nichols, P. F. The dehydration of prunes. Univ. of Calif. Expt. Sta. *Bull. 404* (1929).
7. Cruess, W. V. *Commercial Fruit and Vegetable Products.* 1924, McGraw-Hill Book Co. Revised 1938, 1948. 906 pp.
8. Cruess, W. V. The dietary value of fruits and fruit products. *Fruit Prod. J.*, **19** (8) 230-3; **245, 247, 251** (1940).
9. Cruess, W. V. The effect of pH value on color stability of canned ripe olives. *Proc. Olive Tech. Conf.* (1929).
10. Cruess, W. V. Factors affecting the stability of canned ripe olives. *Food Technol.*, **6**, 110-113 (1952).
11. Cruess, W. V. Fruit candies. *Manufacturing Confectioner*, **11** (3) 33-36; (4) 30-34 (8) 25-29 (1931).
12. Cruess, W. V. Further observations on effect of plain tin and enameled tin cans on olive color. *9th Ann. Tech. Conf. Calif. Olive Assn.* (1930).
13. Cruess, W. V. New outlets for walnuts. *Western Canner and Packer*, **45** (10), 54 (1953).
14. Cruess, W. V. Other uses for prunes. *Western Canner and Packer* (Statistical Number), **44** (6) 177-183 (1952).
15. Cruess, W. V. Pickling green olives. Univ. Calif. Agr. Exp. Sta. *Bull. 498* (1930).
16. Cruess, W. V. Raisins in pudding mixes. *Western Canner and Packer*, **45** (8) 51 (1953).
17. Cruess, W. V. Some factors affecting the quality of ripe olives sterilized at high temperatures. Univ. of Calif. Agr. Exp. Sta. *Bull. 333* (1921).
18. Cruess, W. V. Utilization of fruits in the candy industry. *Fruit Prod. J.*, **19**, 164-166, 174 (1939).
19. Cruess, W. V. Utilization of surplus plums. Univ. Calif. Agr. Exp. Sta. *Bull. 400* (1926).
20. Cruess, W. V., and Armstrong, M. Experiments with anti-oxidants for walnut meats. *Fruit Prod. J.*, **26**, 327-8, 344 (1947).
21. Cruess, W. V., and Christie, A. W. The dehydration of fruits. Univ. of Calif. Expt. Sta. *Bull. 330* (1921).
22. Cruess, W. V., and Guthier, E. H. Bacterial decomposition of olives during pickling. Univ. Calif. Agr. Expt. Sta. *Bull. 368* (1923).
23. Cruess, W. V., and Irish, J. H. Fruit beverage investigations. Univ. Calif. Agr. Expt. Sta. *Bull. 359* (1923).
24. Cruess, W. V., Irish, J. H., and Richert, P. H. Powdered fruit juices. *Pacific Rural Press*, **67**, 741 (1929).
25. Cruess, W. V., and Irish, J. H. The use of fruits in cereals. *Fruit Prod. J.*, **12**, 302-3 (1933).

26. Cruess, W. V., and Marsh, G. L. Fruit jelly juices. *Fruit Prod. J.*, **11**, 325-7 (1932).
27. Cruess, W. V., and Marsh, G. L. Utilization of California fruits. Univ. of Calif. Agr. Expt. Sta. *Circular 349* (1941).
28. Cruess, W. V., and Musco, D. Raisin Utilization Experiments. First Annual Report, Calif. Raisin Advisory Board, pp. 1-14 (1953).
29. Cruess, W. V., O'Neal, R., and Rivera, W. New canned peach products. *Food Technol.*, **5**, 369-372 (1951).
30. Cruess, W. V., Seagrave-Smith, H., and Glazewski, I. G. A. Frozen concentrate makes fresh lemonade. *Quick Frozen Foods*, **9** (9), 86, 87 (April, 1947).
31. Cruess, W. V., and Singh, L. Marmalade juice and jelly juice from citrus fruits. Univ. Calif. Agr. Expt. Sta. *Circ. 243* (1922).
32. Esty, J. R., and Meyer, K. F. Heat resistance of *Bacillus botulinus* spores. *J. Infect. Dis.*, **31**, 650-663 (1922).
33. Freiberg, K., and Cruess, W. V. A study of certain factors affecting the growth of flor yeast. *Applied Microbiol.* (in press).
34. Haas, V., Stadtman, E. R., Stadtman, F. H., and Mackinney, G. Deterioration of dried fruits. I. Effect of sugars and of furfurals. *J. Am. Chem. Soc.*, **70**, 3576-3579 (1948).
35. Heinz Co., H. J. *Nutritional Data.* Published by the Company, Pittsburgh, Pa. Revised edition. 1954.
36. Joslyn, M. A., and Marsh, G. L. Browning of orange juice. *Ind. Eng. Chem.*, **27**, 186-189 (1935).
37. Mackinney, G., and Temmer, O. The deterioration of dried fruit. IV. Spectrophotometric and polarographic studies. *J. Am. Chem. Soc.*, **70**, 3586-3590 (1948).
38. Morgan, Agnes Fay, Perlman, L., and Groody, M. Hemoglobin regenerating properties of prunes. *Food Research*, **9**, 154-163 (1944).
39. Mrak, E. M., and Cruess, W. V. Utilization of surplus prunes. Univ. of Calif. Expt. Sta. *Bull. 483* (1929).
40. Mrak, E. M., Smith, C., Fessler, J., Lambert, H., and Harper, T. The effect of prunes on the plasma CO_2 combining capability and composition of the prune. *J. Nutr.*, **8**, 633-647 (1934).
41. Musco, D. Fruited breakfast cereals. *Amer. Miller and Processor*, **81** (12) (Dec. 1953).
42. Musco, D., and Cruess, W. V. Food rancidity. Studies on deterioration of walnut meats. *J. Agr. Food Chem.*, **2**, 520-525 (1954).
43. Musco, D., Yanase, K., and Lee, L. J. Results of Univ. of California studies on quality of syrups made from low grade raisins. *Food Packer*, **35** (11) (Nov. 1954).
44. Natarajan, C. P., and Mackinney, G. Studies on the darkening of orange juice. *Food Technol.*, **3**, 373-375 (1949).
45. O'Neill, Agnes, and Cruess, W. V. Home preparation of fruit candies. Univ. of Calif. Agr. Expt. Sta. *Circular 10.* Revised 1938.
46. Overholser, E. L., Bjarnasson, S. A., and Cruess, W. V. Storage of perishable fruits at freezing temperatures. Univ. of Calif. Agr. Expt. Sta. *Bull. 324* (1920).
47. Phaff, H. J., Mrak, E. M., and Whelton, R. Control of microbiological food spoilage by fumigation with epoxide. *Food Inds.*, **18**, 23-23, 174-176, 318-332 (1946).
48. Reed, H. M. A new fruit cereal. *Fruit Products J.*, **8** (10) 7-9 (July, 1929).
49. Saywell, L. G. The effect of pears, peaches, apricots and dried sulfured apricots on urinary acidity. *J. Nutr.*, **6**, 397-407 (1933).
50. Shallah, A., and Cruess, W. V. Canning of apricot juice. *Fruit Products J.*, **13**, 208 (1934).
51. Stadtman, E. R., Barker, H. A., Haas, V., Mrak, E. M., and Mackinney, G. Storage of dried fruit. Gas changes during storage of dried apricots. *Ind. Eng. Chem.*, **38**, 324-329 (1946).
52. Stadtman, E. R., Barker, H. A., Haas, V., and Mrak, E. M. Storage of dried fruit. Influence of temperature on deterioration of apricots. *Ind. Eng. Chem.*, **38**, 541-544 (1946).
53. Stadtman, F. N. Deterioration of dried fruits. III. *J. Am. Chem. Soc.*, **70**, 3583 (1948).
54. Strachan, C. C., Atkinson, F. E., Moyls, A. W., and Britton, D. Preparation of pie fruit fillings. *Canadian Food Ind.*, 2-6 (Nov. 1954).
55. Tracy, R. L. Spoilage of olives by Colon Bacilli. *J. Bact.*, **28**, 73-75 (1934).
56. Vaughn, R. H., Douglas, H. C., and Gilliland, R. Production of Spanish type green olives. Univ. of Calif. Agr. Expt. Sta. *Bull. 678* (1943).
57. Wahab, A. Deterioration of dried fruits. II. Identification of furfurals. *J. Am. Chem. Soc.*, **70**, 3580-3582 (1948).
58. Whipple, G. H. Hemoglobin formation as affected by diet and other factors. *J. Am. Med. Assn.*, **104**, 791-795 (1935).

Reconstituting Moisture in Over-dried Popcorn by Blending with Wet Popcorn

W. A. HUELSEN and W. P. BEMIS
Department of Horticulture, University of Illinois

(Manuscript received May 5, 1955)

It is shown in these experiments that blending over-dried with wet popcorn in the proper ratios is an effective method of reconstitution. It is adaptable to large scale operations.

The moisture content of popcorn has been shown by Stewart *(6)* to be one of the most important factors which determines popping expansion. The optimum moisture range will vary according to variety, maturity, and other factors, but it falls within the limits of 11 to 15%. Processors condition their popcorn to secure a nominal moisture content of 13% which generally gives the maximum popping expansion.

In the northern states the moisture content of popcorn at harvest is usually too high, and the crop must be conditioned in specially constructed corn cribs. The conditioning period may extend to the following spring, depending upon the initial moisture content. Thus, a considerable capital investment is required for a building and no return is secured from its contents for many months. In addition there is no method of precisely controlling the moisture content of popcorn while stored in a crib. Huelsen and Thompson *(4)* proposed drying by artificial heat but acknowledged that the final moisture

content could not be controlled with any degree of precision.

Commercial processors are frequently required to handle over-dried popcorn and in the southwestern growing areas much of the crop becomes too dry while still in the field. Thus, reconditioning is fully as important as initial drying and must be considered an integral part of processing for market. The most common method of reconditioning consists of adding the proper quantity of water. This is done in various ways, but the method is poorly adapted to large commercial operations. Dexter *(3)* proposed controlling the humidity of the air with solutions of NaCl, but the popcorn must be stored in sealed containers, or in special rooms. Bemis and Huelsen *(1)* proposed steam blanching as a feasible commercial method for reconditioning over-dried popcorn.

Blending over-dried popcorn with a lot that is too wet has never been suggested in published literature. Such a method is readily adaptable to large scale operations, however, as suitable machinery is available. Blending two or more lots to produce a homogeneous sample is a common practice in the seed trade.

MATERIALS AND METHODS

The four hybrids Iopop 5, Iopop 6, Purdue *32* and Purdue *202* were used in the preliminary experiments, but in the final blending experiments only Iopop 6 and Purdue *202* were used. Iopop 6 for blending in the final experiments was harvested at field moistures ranging from 16.1 to *22.05%*; Purdue *202* for blending ranged from 18.3 to *24.60%* moisture. All lots were dried in a specially constructed corn dryer to varying percentages of moisture. They are designated in the subsequent discussion as "dry" samples because the moisture contents were below 12.5%. According to the oven moisture tests used in these experiments, this moisture content usually gives the maximum popping expansion. All blends were stored at room temperature averaging 80° F. (26.7° C.).

Moisture determinations (wet basis) were made in duplicate with 100 g. shelled samples placed in 307 x 306 open cans. Drying equipment consisted of a large forced draft Despatch oven with thermostatic controls operated at 176° F. (80° C.). The samples were dried for 168 hours. The dry weights checked closely with those obtained from a vacuum oven test, as shown in previous work by Bemis and Huelsen *(1)*.

Samples were popped in the so-called "official volume tester" at 470° F. (243.3° C.). Hydrogenated coconut oil was used for seasoning. This tester is equipped with a standard 6 oz. cup, and popping expansion is expressed as "volumes" in relation to the measuring cup. Thus, an expansion of 30 volumes equals 30 standard cups, the measurements being taken in a calibrated cylinder forming part of the tester. Huelsen and Thompson *(4)* demonstrated that the samples measured in the standard cup varied considerably in weight. Their method—measuring 5 samples, weighing each, averaging the weights, and then weighing the actual popping samples in duplicate—was followed in this work.

All blending except where mentioned otherwise was done on a laboratory size "Twin Shell Dry Blender."[a] The blender consists of 2 plastic cylinders joined together to form a V shape. Each cylinder is provided with a removable plastic cover. The outfit revolves on a motor driven shaft at 37 r.p.m. The blending was timed for completion in exactly 3 minutes, or 111 revolutions. The principle of the blender is that with each revolution the contents are divided in half as the V shaped cylinders turn to the inverted position. A test run with equal quantities of white and yellow popcorn showed that at the end of the 3 minute run there was an equal division of the 2 colors in an aliquot sample.

Part of the preliminary experiments consisted of mixing white kernels (Iopop 5) with yellow kernels (Purdue 32). Three blends were prepared; namely, 50-50, 25-75 and 75-25, respectively, of Iopop 5 and Purdue 32. The blends were mixed by hand and sealed in Mason jars.

The blends of the main experiments consisted of 2300 g. aliquots, each of which completely filled a 2 qt. Mason jar taken from 13 over-dried lots of Iopop 6 (Table 6) and 11 over-dried lots of Purdue 202 (Table 7). Each of these over-dried lots was blended with one wet lot of each variety in amounts to bring the theoretical average moisture to 12.5%. The method of calculation is exemplified below.[b]

RESULTS AND DISCUSSION

Moisture absorption by kernels. Table 1 shows the rate of moisture absorption of two lots of Purdue 202 popcorn held at a controlled temperature of 68° F. (20° C.) in desiccators containing suitable salt solutions. These were prepared as explained by McCollum *(5)*. The lot with 8.10% initial moisture lost moisture at .1035 in. v.p (2.629 mm.) and the lot with 10.90% initial moisture remained practically static at a vapor pressure as high as .2414 in. (6.132 mm.). The rates of absorption by the kernels were rapid at the three highest vapor pressures and the two lots did not differ materially in this respect. When two lots of popcorn, which differ by only 3.35% moisture (Table 3) are mixed in equal quantities the increase in vapor pressure of the air in a sealed container will be relatively slight in comparison with the vapor pressure of the one with the lower moisture content when stored alone. Thus, with a small increase in vapor pressure, moisture diffusion was slow (Table 1), which accounted for the fact that after 158 days' storage two of the lots in Table 3 had not reached equilibrium. Moisture content at the time of popping is not highly critical; however, as shown by Stewart *(6)*, Huelsen and Thompson *(4)*, and others; a commercially acceptable expansion of 30 volumes may be expected even when the two lots making up a blend differ by as much as 1 to 1.5% moisture.

A further experiment (Table 2) consisted of exposing the kernels of 4 hybrids to a nominally saturated atmosphere for various lengths of time. The kernels were placed in dry open petri dishes which were stored in desiccators containing distilled water. The results (Table 2) show that the moisture content approximately doubled after 21 hours and more than tripled after 191 hours. Allowing for differences in the initial moisture content the 4 hybrids absorbed moisture at a similar and comparatively rapid rate. This indicates that equilibration of moisture would take place in a

[a] Manufactured by the Patterson-Kelley Co., E. Stroudsburg, Pa.

[b] The problem (from line 1, Table 6) is how much popcorn with 16.9% moisture must be added to 100 g. corn with 8.8% moisture to make a blend with 12.5% moisture? Subtracting .125 — .088 = .037 and .169 — .125 = .044. The equation will be $\frac{100}{.044} = \frac{X}{0.37}$ which solves for 84.09 g. of 16.9% popcorn added to 100 g. of 8.8% popcorn. The ratios are calculated as follows: $\frac{100}{184.09} \times 100 = 54.32\%$ dry corn by weight and 100 — 54.32 = 45.68% wet corn by weight.

TABLE 1

Moisture changes in kernels of Purdue 202 popcorn held in desiccators at 68° F. (20° C.) under varying vapor pressures

Vapor pressure [1]	Changes in moisture after storage of	
	12 hr.	35 hr.
	%	%
Initial	8.10	
.1035	—.28	—.62
.2414	.11	.21
.3863	.42	.86
.5174	1.03	2.37
.6553	2.79	5.86
Initial	10.90	
.1035	—.38	—.91
.2414	.00	—.04
.3863	.36	.68
.5174	1.02	2.03
.6553	2.71	5.42

[1] As inches of Hg at 68° F. (20° C.), 29.921 in. barometric pressure. The five vapor pressures are equivalent to 15, 35, 56, 75 and 95% relative humidity at 68° F.

TABLE 2

Rate of moisture absorption of undamaged kernels held in a saturated atmosphere at 80° F. (26.7° C.)

Hybrid	Moisture content			
	Initial	After 21 hours	After 55 hours	After 191 hours
	%	%	%	%
Iopop 5	7.98	17.07	20.71	28.45
Iopop 6 Lot 1	8.28	16.38	20.80	28.96
Iopop 6 Lot 2	6.34	14.82	19.89	27.78
Purdue 32	8.54	14.64	18.90	26.90
Purdue 202	6.36	12.60	17.38	26.13
Average	7.50	15.10	19.54	27.64

reasonable length of time in a blend of two or more lots of popcorn having varying moisture contents.

Preliminary equilibration test. This test consisted of mixing white Iopop 5 kernels containing 9.95% moisture with yellow Purdue 32 kernels containing 13.3% moisture in various ratios. The results in Table 3 were obtained by separating the yellow and white kernels manually and determining the respective moistures. Exposure to air during separation caused some loss of moisture, as shown by the successive reductions in the calculated average moistures at each sampling. The moisture tests show that even after 158 days the two varieties had not reached equilibrium, but for most practical purposes the storage period of 31 days would be sufficient. Bemis and Huelsen *(2)* found that during drying the kernels lost most of their moisture directly

TABLE 3

Equilibration rates of white Iopop 5 and yellow Purdue 32 popcorn with different moisture contents stored in sealed containers at room temperatures. Three lots were mixed in various ratios and a fourth lot consisted of equal weights of two varieties separated so that they were not in physical contact

Hybrid	Ratio of each variety by weight	How stored	Moisture content		
			Initial	After 31 days	After 158 days
	%		%	%	%
Iopop 5	25	mixed	9.95	11.50	11.50
Purdue 32	75	mixed	13.30	12.30	12.20
Averages [1]			12.46	12.10	12.02
Iopop 5	50	mixed	9.95	10.80	11.10
Purdue 32	50	mixed	13.30	11.90	11.45
Averages [1]			11.62	11.35	11.28
Iopop 5	75	mixed	9.95	10.20	.....
Purdue 32	25	mixed	13.30	10.80	.....
Averages [1]			10.79	10.35	
Iopop 5	50	separated	9.95	10.70	10.75
Purdue 32	50	separated	13.30	12.30	11.55
Averages [1]			11.62	11.50	11.15

[1] Calculated.

through the pericarp rather than through the hilar closing layer. Thus, in a blend, moisture may be transferred from the wet to the dry kernels partly by direct contact, but probably most of the transfer is by means of diffusion from the increased vapor pressure of the air in a sealed container. This would be indicated by the fourth lot in Table 3. Although stored in the same container, the two hybrids were not in physical contact and any gain or loss of moisture was by means of diffusion. Table 3 shows that the moisture content of Iopop 5 reached 10.70% after 31 days storage which is almost equal to the 10.80% of Iopop 5 in the 50-50 mixture.

Equilibration in relation to kernel moisture. The purpose of the experiments recorded in Tables 4 and 5 was to determine the relationship between equilibration time and the moisture contents of the blends. The blends were made from a single lot of each hybrid. After shelling, part of each lot was dried for 8 hours to a low moisture. The blends were then calculated for a series ranging between 10 and 14% moisture by 0.5% steps. The maximum popping expansion of both hybrids was attained with few exceptions by the end of 43 days, but for practical purposes 14 days equilibration would have been sufficient. Of course, even at the end of 43 days the moisture contents of the two components

TABLE 4

Effect on popping expansion of blending over-dried and undried Iopop 6 popcorn from the same lot so that moisture contents of blend varied theoretically from below to above optimum moisture for popping

Moisture in blended lots [1]		Ratio of dry to wet corn		Popping expansion after blending as percentage of maximum at time shown				Maximum popping expansion
Calculated	Actual	Dry	Wet	24 hr.	14 days	43 days	110 days	
%	%	%	%	%	%	%	%	Vol.
10.0	9.8	73.36	26.64	89.9	100.0	97.2	98.9	27.8
10.5	10.0	67.93	32.07	89.7	96.6	100.0	98.3	29.0
11.0	10.1	62.50	37.50	86.7	98.3	100.0	96.7	30.0
11.5	10.6	57.06	42.94	89.4	97.7	100.0	98.7	30.2
12.0	11.4	51.63	48.37	86.0	97.4	100.0	97.4	30.8
12.5	11.6	46.20	53.80	73.7	95.5	100.0	97.8	31.2
13.0	12.0	40.76	59.24	85.6	99.3	99.3	100.0	29.2
13.5	12.5	35.33	64.67	74.4	90.2	100.0	99.2	26.2
14.0	13.2	29.89	70.11	78.1	95.3	100.0	100.0	21.5

[1] The popcorn was harvested at 16.75% field moisture which is the "wet" part of the lot. The "dry" portion was dried after shelling for 8 hr. at 110° F. to 7.55% moisture. Before drying popping expansion was 8 vol. and after drying 20.0 vol.

TABLE 5

Effect on popping expansion of blending over-dried and undried Purdue 202 popcorn from the same lot so that moisture contents of blend varied theoretically from below to above optimum moisture for popping

Moisture in blended lots[1]		Ratio of dry to wet corn		Popping expansion after blending as percentage of maximum at time shown				Maximum popping expansion
Calculated	Actual	Dry	Wet	24 hr.	14 days	43 days	110 days	
%	%	%	%	%	%	%	%	*Vol.*
10.0	9.8	71.04	28.96	86.4	94.2	100.0	95.6	29.5
10.5	10.4	65.57	34.43	83.6	98.4	100.0	100.0	30.5
11.0	10.6	60.11	39.89	86.5	99.4	100.0	99.4	31.2
11.5	11.4	54.64	45.36	84.2	97.0	100.0	100.0	33.0
12.0	11.6	49.18	50.82	75.9	100.0	97.6	96.5	34.0
12.5	12.1	43.72	56.28	68.0	97.9	100.0	100.0	33.5
13.0	12.1	38.25	61.75	60.6	97.0	100.0	99.4	33.0
13.5	13.0	32.79	67.22	70.6	98.0	100.0	96.1	25.5
14.0	13.8	27.32	72.68	78.0	93.7	97.6	100.0	20.5

[1] The popcorn was harvested at 16.5% field moisture which is the "wet" part of the lot. The "dry" portion was dried after shelling for 8 hours at 110° F. to 7.35% moisture. Before drying popping expansion was 8 vol. and after drying 18.5 vol.

in the blend would not have been entirely equal, as indicated by Table 3.

It will be noted that after reaching the maximum (Tables 4 and 5) the popping expansions tended to decrease as the storage period lengthened. These decreases were small and within the limits of sampling error, but they were consistent. They were not due to loss of moisture, because if this were true the blends which had a low popping expansion due to their high moisture content would show increases instead of decreases as the storage period lengthened.

The results in Tables 4 and 5 also show that the popping expansions of the blends increased until the optimum moisture content was reached and then declined as moisture increased further. Lots reconstituted by means of adding water have the same trends.

Blending experiments. The lots in Tables 6 and 7 are arranged in the order of ascending moisture content of the dry component of the blends as shown in column 1. This was done for the sake of convenience and does not constitute a series; each was a separate lot, dried by artificial heat under different conditions. The aim was to bring the moisture contents of each lot to 12.5% by means of blending with the wet lot listed at the bottom of column 1 in Tables 6 and 7. None of the blended lots averaged 12.5% moisture, due probably to the moisture lost during handling and blending. The 3 sets of popping expansions appearing in Tables 6 and 7, consist of (a) the original, (b) reconstituted with water to 12.5% moisture and (c) blended. In general, the blended lots popped as well as those reconstituted with the water. In fact, the averages were practically the same. This similarity is striking, particularly as the moisture content of the blended lots was below the optimum 12.5% whereas the same lots reconstituted with water were at or very close to it.

All but one lot in Tables 6 and 7 reached 90% or more of the maximum popping expansion after 14 days' storage. After 49 days' storage only one lot popped below 95% of the maximum.

The blends in Tables 6 and 7 ranged from an approximate 50-50 ratio to an approximate 80-20 ratio of dry to wet popcorn, but despite the wide differences in the ratios the results show that the changes in popping expansion after 14 days were very slight, thus confirming the conclusions from Tables 4 and 5. For most purposes a 14-day storage period would be sufficient when two lots of popcorn are blended.

SUMMARY

Popcorn was stored in desiccators under five different vapor pressures. Under low vapor pressures there was

TABLE 6

Blending 13 lots of over-dried Iopop 6 popcorn with a wet sample taken directly from the field in the proper proportions to bring the blend to 12.5% theoretical moisture

Original samples			After blending		Blending ratios		Popping expansion after blending as percentage of maximum at time shown			
	Popping expansion									
Moisture	At moisture content in Col. 1	Reconstituted with water to 12.5%	Maximum popping expansion	Moisture content	Dry	Wet	24 hr.	14 days	49 days	119 days
%	*Vol.*	*Vol.*	*Vol.*	%	%	%	%	%	%	%
8.8	26.0	32.0	30.5	12.0	54.32	45.68	80.3	91.8	95.1	100.0
9.5	29.0	33.0	30.2	12.0	59.45	40.55	81.0	95.9	100.0	100.0
9.6	30.0	30.8	31.2	12.2	60.28	39.72	83.2	94.4	96.0	100.0
9.7	30.0	32.5	31.5	11.8	61.13	38.87	88.9	96.0	100.0	100.0
9.8	29.0	33.0	32.8	11.7	61.96	38.04	89.3	96.2	100.0	98.5
10.2	32.0	33.2	32.5	12.0	65.66	34.34	90.0	98.5	100.0	98.5
10.5	34.0	33.5	32.5	12.0	68.78	31.22	90.0	96.9	100.0	99.2
10.5	30.0	30.8	31.5	11.8	68.78	31.22	92.1	92.1	97.6	100.0
10.6	31.0	32.2	32.5	11.9	69.83	30.17	92.3	96.2	96.9	100.0
11.0	33.0	32.5	32.5	11.5	74.57	25.43	93.8	96.2	98.5	100.0
11.0	31.5	31.2	32.2	11.7	74.57	25.43	96.1	93.8	98.4	100.0
11.2	32.0	32.8	32.8	11.9	77.22	22.78	94.6	94.6	96.2	100.0
11.5	34.0	35.2	34.8	11.0	81.50	18.50	97.1	95.7	100.0	97.8
16.9[1]	8.0									
Average		32.5	32.1				89.9	95.3	98.4	99.5

[1] Wet sample.

TABLE 7

Blending 11 lots of over-dried Purdue 202 popcorn with a wet sample taken directly from the field in the proper proportions to bring the blend to 12.5% theoretical moisture

Original samples			After blending		Blending ratios		Popping expansion after blending as percentage of maximum at time shown			
	Popping expansion									
Moisture	At moisture content in Col. 1	Reconstituted to 12.5% moisture	Maximum popping expansion	Moisture content	Dry	Wet	24 hr.	14 days	49 days	119 days
%	*Vol.*	*Vol.*	*Vol.*	%	%	%	%	%	%	%
9.4	27.0	32.0	32.5	12.1	51.18	48.82	70.8	89.2	100.0	100.0
9.6	33.0	36.5	34.0	12.0	52.86	47.14	75.0	95.6	100.0	98.5
9.7	30.0	32.8	32.8	12.2	53.71	46.29	77.9	98.5	96.2	100.0
10.0	32.0	36.8	34.0	11.8	56.53	43.47	77.9	96.3	98.5	100.0
10.2	30.0	33.2	34.2	11.7	58.55	41.45	75.9	92.7	96.3	100.0
10.7	35.0	37.0	36.0	11.7	64.35	35.65	83.3	100.0	97.2	96.5
10.8	32.5	34.5	34.5	12.0	65.66	34.34	82.6	94.9	100.0	97.1
10.9	36.0	36.2	35.5	12.0	67.03	32.97	80.3	97.2	98.6	100.0
11.4	34.5	36.5	35.8	11.8	74.74	25.26	83.9	100.0	99.3	98.7
11.6	33.0	33.5	34.0	12.4	78.31	21.69	83.8	94.1	94.1	100.0
11.6	34.0	35.0	35.0	11.9	78.31	21.69	91.4	99.3	97.8	100.0
15.75[1]	8.0									
Average		34.9	34.4				80.3	96.2	98.0	99.2

[1] Wet sample.

a loss of moisture from the kernels which changed to progressively greater absorption as the vapor pressures increased. In a nominally saturated atmosphere the absorption of moisture was very rapid and four different hybrids behaved in practically the same manner. The experiments showed that in spite of their hardness and apparent impermeability popcorn kernels were able to absorb moisture in the vapor phase very rapidly.

Transfer of moisture from dry to wet popcorn kernels was demonstrated by mixing white and yellow kernels having different moisture contents and sealing the blends in glass jars. Transfer of moisture would be by direct contact and by means of the vapor phase. Samples were taken periodically and after manual separation the respective moisture contents of the white and yellow kernels were determined. For practical purposes equilibration had been attained at the first sampling, namely 31 days after blending.

Over-dried and wet popcorn from the same lot was blended so that the calculated moisture content of the blend ranged from 10 to 14% by 0.5% steps. The blends were popped periodically and out of 18 lots of both hybrids, two lots reached the maximum popping expansion in 14 days, 14 in 43 days, and two in 110 days. Out of the 18 lots tested all reached 90% or more of their maximum popping expansion after 14 days' storage. For practical purposes 14 days' storage of a blend at 80° F. (26.7° C.) is considered sufficient.

A total of 24 different over-dried lots was blended with wet corn so that the blends would average 12.5% moisture. The blends were sampled periodically and popped. After 14 days' storage the 13 lots of Iopop 6 averaged 95.3% of the maximum popping expansion and the 11 lots of Purdue 202 averaged 96.2%. Storage for 49 days increased these averages to 98.4% and 98.0%, respectively, thus indicating that 14 days' storage was sufficient.

The 24 lots were also reconstituted to 12.5% moisture with water. The popping expansions of the lots thus reconstituted did not differ materially from those reconstituted by blending. The averages differed by less than 0.5 volume. Blending over-dried popcorn with wet popcorn in the proper ratios is recommended as one commercial method of reconstitution.

LITERATURE CITED

1. Bemis, W. P., and Huelsen, W. A. Reconstitution of moisture in popcorn by steam blanching. *Food Technol.*, **7**, 415-419 (1953).
2. Bemis, W. P., and Huelsen, W. A. Dehydration and rehydration in relation to endosperm fracturing of popcorn. *Proc. Am. Soc. Hort. Sci. In press.*
3. Dexter, S. T. Conditioning popcorn to the proper moisture content for best popping. Mich. Agr. Exp. Sta. Quart. *Bull.*, **29**, 64-69 (1946).
4. Huelsen, W. A., and Thompson, A. E. Artificial drying of popcorn in relation to popping expansion. *Proc. Am. Soc. Hort. Sci.*, **60**, 341-350 (1952).
5. McCollum, J. P. Factors affecting cotyledonal cracking during the germination of beans *(Phaseolus vulgaris)*. *Plant Physiol.*, **28**, 267-274 (1953).
6. Stewart, F. C. The relation of moisture content and certain other factors to the popping of popcorn. N. Y. Agr. Exp. Sta. *Bull. 505* (1923).

Reproducibility of Results in Consumer Wine-Preference Surveys

F. FILIPELLO, H. W. BERG, ELLY HINREINER, AND A. D. WEBB
University of California, Davis, California

(Manuscript received April 11, 1955)

In the course of testing various wines for consumer acceptance and preference, different methods of presentation and types of questionnaires were used *(1)*. The studies were conducted in 1951, 1952, 1953 and 1954, with California fairs as locales.

In 1953, at the California State Fair, Sacramento, and the Fresno District Fair, a questionnaire was used requiring a statement of age group, sex, and frequency of use of wine. In paired comparisons, two vertical hedonic scales *(3)* were included in the questionnaire to denote the degree of liking for each wine. In single sample presentations one scale was used. To eliminate any possible bias due to order of presentation of the samples in paired comparisons, the order of serving the wines was reversed periodically throughout each test. Some 16,330 persons participated in the survey out of a total of more than 1,000,000 fairgoers.

Since it had given reasonable success in 1953, the hedonic scale was employed again in 1954, at the same two fairs, for various other wine comparisons. A total of 17,338 out of the 1,060,000 fairgoers participated.

Of the questionnaires received, only 5% were rejected in each year due to incomplete information in hedonic scoring. This would indicate that the type of questionnaire used was easily understandable.

Table 1 gives the percent distribution by age, sex and frequency of use of wine categories of the survey participants at the State and Fresno Fairs for 2 years, 1953 and 1954. With few exceptions, the percentages in each category for each fair remained fairly constant for the 2 years. It is interesting to note that more males participated than did females. Also, the distribution shows that the majority of the participants are fairly frequent users of wine; therefore, this sampling does not represent a true cross-section of the population of the United States as a whole.

TABLE 1
Distribution of survey participants for 1953 and 1954 (in percent)

		Age:	21-35	35-50	Over 50
1953	Sacramento		48.2	33.0	18.8
	Fresno		54.6	32.2	13.2
1954	Sacramento		47.4	32.9	19.7
	Fresno		47.0	33.9	19.1
		Sex:	Male	Female	
1953	Sacramento		56.3	43.7	
	Fresno		60.5	39.5	
1954	Sacramento		56.0	44.0	
	Fresno		60.0	40.0	
		Frequency of use[1]:	1	2	3
1953	Sacramento		30.8	48.1	21.1
	Fresno		26.2	45.3	28.5
1954	Sacramento		36.8	46.1	17.1
	Fresno		28.0	45.2	26.8

[1] Frequency of use:
1—several times a week.
2—few times a month.
3—few times a year or never.

In 1953, only a few pairs of wine were compared and there was a large number of responses for each comparison; in 1954, more wines were compared with fewer judgments for each. It was hoped that the smaller numbers employed would still give reliable results. Table 2 gives the number of participants for all wines tested for the 2 years.

The hedonic scale used was a 9-point scale in a column, ranging from *like extremely* at the top to *dislike extremely* at the bottom. This particular arrangement was chosen for convenience only, since no definite difference has been found by reversal of the scale in other food tests *(3)*. For statistical analysis, the scale was translated by assigning values from 1 to 9, the lowest number corresponding to *dislike extremely* and on up to 9, denoting *like extremely*. These numerical ratings were given for the same reason as that offered by Peryam and Girardot *(3)*; i.e., to enable a statistical analysis of the results to be made. Numerical procedures appear justified until more appropriate techniques can be found. There is some evidence supporting an assumption of normality of subjective distribution for 20 food items *(2)*.

TABLE 2
Participation at California fairs for two years 1953 and 1954

	Participation
1953	
Red table wine (0.2% reducing sugar vs. 1.4%)	3775
Port wine (18% vs. 20% alcohol)	3173
Port wine (0.4% vs. 0.5% total acid)	3266
Sparkling Muscat—single test	4498
Sparkling Muscat—dual test	899
Port wine—triangular	719
1954	16330
Sherry wine quality	
Sherry No. 1 vs. Sherry No. 2	1763
Sherry No. 1 vs. Sherry No. 3	1634
Sherry No. 1 vs. Sherry No. 4	804
Sherry (18% vs. 20% alcohol)	1786
Port wine (experimental vs. commercial)	264
Rose table wine (0.2% r.s. vs. 3.0% r.s.)	1034
Concord wine No. 1 vs. Concord No. 2	985
Concord wine No. 1 vs. Concord No. 3	1525
Uncarbonated Muscat wine	2075
Light sweet Muscat wine	1218
Carbonated Muscat wine—dual test	1642
Carbonated Muscat wine—single test	1608
	16338[1]

[1] 1954 participation corrected for rejects.

The mean hedonic score was taken for each wine and the difference between two means in any one paired comparison was tested for significance using "Student's" *t*-test *(4)*. It was found that a difference of 0.25 unit was statistically significant when employing numbers of 1000 or more up to 2000, and for larger numbers the significant difference was 0.20 unit.

To test the general consistency of results for a single

TABLE 3

Mean scores for identical wines in different comparisons (in hedonic rating units)

	Age			Frequency of use[1]		
	21-35	35-50	over 50	1	2	3
Sherry No. 1 (1954)						
vs. Sherry No. 2	6.7	7.0	7.4	7.1	6.9	6.6
vs. Sherry No. 3	6.8	7.0	7.3	7.1	7.0	6.7
vs. Sherry No. 4	6.8	7.3	7.4	7.3	7.0	6.9
Concord No. 1 (1954)						
vs. Concord No. 2	7.4	7.6	7.8	7.6	7.6	7.5
vs. Concord No. 3	7.3	7.5	7.7	7.5	7.5	7.3
vs. carbonated Muscat	7.5	7.6	7.7	7.5	7.5	7.7
Uncarbonated Muscat (1954)						
vs. light sweet Musc.	7.2	7.3	7.7	7.4	7.2	7.4
vs. carbonated Musc.	7.3	7.5	7.7	7.4	7.4	7.4
Carbonated Muscat (1954) single sample	7.8	7.9	7.9	7.9	7.9	7.9
Sparkling Muscat (1953) single sample	7.8	7.9	8.1	7.9	7.9	7.9

[1] Frequency of use of wine:
1—several times a week.
2—few times a month.
3—few times a year or never.

wine, average scores by age and frequency of use categories are tabulated in Table 3 for each wine judged in more than one comparison. The average scores for Sherry No. 1 when compared with Sherry No. 2, Sherry No. 3 and Sherry No. 4 are given, as well as those for Concord wine No. 1 when tested against Concord No. 2, Concord No. 3 and carbonated Muscat wine; and those for uncarbonated Muscat wine when served against carbonated Muscat and light sweet Muscat wine. Also given is a comparison of the average scores of the carbonated Muscat wine (1954), served alone, and a somewhat similar sparkling Muscat wine, served as a single sample in 1953. It is evident that there was exceedingly good accord between values of the mean throughout all categories for each wine, despite the fact that each test was performed on different days and involved different individual populations. The largest discrepancies occurred in the lowest frequency of use of wine category. The comparison of the results of the carbonated Muscat (1954) and the sparkling Muscat (1953) shows very good agreement, even though taken a year apart.

A comparison was made of the results from each fair, in cases where identical tests were presented at both fairs. Table 4 demonstrates that the 1953 Sacramento averages were slightly higher, in general, than the Fresno average scores; in the case of the light red wines, the Sacramento scores were substantially higher. In 1954, there were no significant differences in scores between the two fairs for the wines tested.

TABLE 4

Mean values for wines tested at two fairs (in hedonic units)

	Sacramento	Fresno	Average both fairs
1953			
Port 18% alcohol	7.4	7.2	7.3
Port 20% alcohol	7.2	6.9	7.1
Port 0.4% total acid	7.3	6.9	7.2
Port 0.5% total acid	7.3	7.1	7.2
Light red wine (0.2% r.s.[1])	6.8	6.1	6.6
Light red wine (1.4% r.s.[1])	7.5	7.0	7.3
Sparkling Muscat	7.9	7.9	7.9
1954			
Sherry No. 1	6.9	7.1	7.0
Sherry No. 2	6.8	6.8	6.8
Sherry No. 3	6.7	6.7	6.7
Sherry 18% alcohol	6.8	7.0	6.9
Sherry 20% alcohol	6.7	6.7	6.7
Uncarbonated Muscat	7.4	7.4	7.4
Carbonated Muscat	7.8	8.0	7.8

[1] r.s. = reducing sugar.

SUMMARY

Reproducibility of results was tested in consumer wine-preference studies at two California fairs. The nine-point hedonic scale was employed in these investigations.

In general, the percentage distribution of participants by age, sex and frequency of use of wine categories was fairly constant for each fair for the two years of testing, 1953 and 1954.

When the same wine was used in different comparisons, it achieved nearly identical hedonic average ratings in all comparisons.

When identical comparisons were made at the two fairs, the results for 1953 showed slightly higher mean values at Sacramento, while no significant differences were noted for 1954.

Acknowledgment

Funds for this investigation were made available by contract with the Wine Advisory Board.

LITERATURE CITED

1. Berg, H. W., Filipello, F., Hinreiner, Elly, and Sawyer, F. M. Consumer wine-preference studies at California fairs. *Food Technol.*, **9**, 90-93 (1955).
2. Jones, Lyle V. Psychophysics and the normality assumption: An experimental report. *Food Acceptance Testing Methodology—A Symposium.* Quartermaster Food and Container Institute for the Armed Forces. Chicago, Ill. (1954).
3. Peryam, D. R., and Girardot, N. F. Advanced taste test method. *Food Eng.*, **24** (7), 58-61, 194 (1952).
4. Walker, Helen M., and Lev, Joseph. *Statistical Inference.* 1953. Henry Holt and Co., New York, N. Y.

Rates of Nonenzymatic Browning of White Potato During Dehydration[a]

CARL E. HENDEL, VERNON G. SILVEIRA, AND W. O. HARRINGTON

Western Utilization Research Branch, Agricultural Research Service, United States Department of Agriculture, Albany 10, California

(Manuscript received May 7, 1955)

To obtain information for use in dehydrator design, rates of nonenzymatic browning have been determined for white potato half-dice held at a series of constant moisture levels and temperatures encompassing the ranges encountered in commercial dehydration. Heat damage, moisture level, and piece temperature were also measured for half-dice in a series of cabinet-drying runs. The data can be used in estimating effects of various alternatives in dehydrator design and operation. On the basis of such estimates, the significance of conditions at the finishing end of dehydration is discussed.

Dehydrated diced potato is one of the most important of the dehydrated vegetable products. This fact is shown by both military procurements and increasing civilian use, chiefly for remanufacture.

There has been a lack of information on which to base dehydrator design and operation. Nomographs for estimation of tray drying time of white potato half-dice were developed at this Branch during World War II *(1)*, and a method for estimating the temperature of the drying vegetable piece was recently proposed by W. B. Van Arsdel of this Laboratory. However, no quantitative information has been available on the rate at which quality of product changes during dehydration. Heat damage, or nonenzymatic browning, is the quality change that normally limits the capacity of a vegetable drier.

In the work reported here, potato half-dice were heat-damaged at various constant moisture levels and constant temperatures covering the ranges that exist during commercial dehydration. The rates of browning were then determined by a soluble-color procedure. The data are presented as a chart that can be used, with drying-rate and piece-temperature information, for estimation of the approximate amount of browning during drying.

To test the accuracy of such estimates, a second part of this work consisted of cabinet-drying tests in which the moisture content, piece temperature, and amount of browning were measured periodically.

EXPERIMENTAL

Raw material. Russet Burbank potatoes grown at the Aberdeen Branch of the Idaho Agricultural Experiment Station were used for the principal phases of this study. To improve uniformity, they were gravity graded on receipt, shortly after harvest. The middle specific-gravity group (sp. gr. 1.075 to 1.090) was selected; it was 60% of the total. The potatoes in this gravity group were well mixed. They were then held in 50° F. storage until processed, 10 to 12 weeks later. The temperature of 50° F. was selected because potatoes held at this temperature were expected to have good quality for processing. Also, results of Wright *et al. (16)*, Denny and Thornton *(4)*, and Ross *et al. (11)* indicated that the reducing-sugar content would change very little during the processing period if the potatoes had been held at this temperature until the sugar content had reached an equilibrium value. Constancy of the raw material was necessary because the processing covered a period of 15 days. The data in Table 1 show that there was no apparent change in the potatoes during this 15-day period, as judged by nitrogen and sugar contents.

Constant-moisture heat damage. Samples to be heat damaged at constant moisture level and constant temperature were prepared by abrasive peeling, trimming, cutting into half-dice (⅛ x ⅜ x 3/10-inch), washing to remove free starch, and blanching 3 minutes in steam at 212° F. Then, except for the material to be heat damaged at the initial moisture content, they were dehydrated to various moisture levels in a vacuum shelf drier. Expressed on a dry-solids basis (moisture-free basis, MFB), for convenient use in engineering calculations, the moisture contents of the various portions were 110, 33, and 9.4% (52.4, 24.8, and 8.8% moisture, as-received basis). On the moisture-free basis, the undried material had a moisture content of 370% (78.7% moisture, as-received basis). Portions of the 9.4% material were later adjusted to 15.0% moisture (by water vapor addition in vacuum) and to 4.9% moisture (by vacuum desiccation over calcium oxide).

TABLE 1

Sugar and nitrogen contents of potato dice dehydrated during the 15-day processing period

Dates dehydrated	Sugars, % MFB		Nitrogen, % MFB	
	Reducing	Total	Amino	Total
January 3	1.16	1.78	0.56	1.32
January 6	1.09	1.70	0.55	1.29
January 10	1.14	1.66	0.55	1.26
January 12	1.10	1.65	0.55	1.27
January 17	1.11	1.68	0.55	1.31

The shelf temperature of the vacuum drier was 95° F. (35° C.), and the pressure was 4 mm. of mercury. In order that the moisture content of the partially dried samples (110 and 33% moisture) might be as uniform as possible, these lots were turned on the drying trays every 20 minutes during drying. In addition, after partial drying they were held in evacuated desiccators for 7 days at 34° F. (1° C.). They were then sealed in fruit-enameled 307 x 409 cans, with 40 g. of material (MFB) per can. Larger amounts were not used because heat transfer would have been slower when the cans were pre-heated before heat damaging.

Before they were placed in the constant-temperature water baths for heat damage, the cans were pre-heated in a separate container equipped with a can rotator. The cans were rotated for 1-minute intervals when first placed under the rollers and again after 5, 10, and 15 minutes. The rotator was not kept running continuously, for this would have caused break-up of some of the high-moisture pieces. At the end of the 15-minute period the contents of the cans were within about 1° F. of the bath temperature, and the cans were transferred to the water baths. The cans were kept submerged in the water baths, which were maintained within 0.2° C. (0.4° F.) of the designated tem-

[a] Presented at the Fourteenth Annual Meeting of the Institute of Food Technologists, Los Angeles, California, June 29, 1954.

perature. The 15-minute pre-heating time, a small fraction of the time the samples were in the bath, was neglected in the subsequent calculation of rate of browning. The samples, removed periodically from the baths, were then vacuum-dried in the vacuum shelf drier, canned (nitrogen-pack), and held at 34° F. for later measure of the degree of heat damage. Numerous bacteriological counts were made on the higher moisture samples; those series in which spoilage had occurred were discarded. To compare effects of air and vacuum, certain of the cans were evacuated before sealing. These were tested for vacuum at the end of heat damaging and the samples were discarded in those few instances in which air had leaked into the cans. For the air-packed samples, gas analyses showed that at the end of heat damaging the oxygen content of the container atmosphere was at least 85%, and usually 90 to 95%, of its initial value.

Cabinet drying. Samples heat damaged under usual drying conditions were prepared as described above and were dried in a cabinet drier on wire mesh trays at a tray loading of 1½ lb./sq. ft., with six 1½ x 2-foot trays of dice for each of the 8 drying runs. Drying conditions—uniformity of tray loading, dry-bulb temperature, wet-bulb temperature, and air velocity—were carefully controlled. Air temperature was maintained within ± 1° F. of the desired temperature. Piece temperature during drying was measured with a 3-point potentiometer. Two thermocouples were connected in parallel to each of the leads of the potentiometer, each thermocouple juncture being in the center of one of the dice, with 4 dice strung on the thermocouple wire to minimize heat transfer along the wire. Samples were removed from the drier periodically, and drying was completed in the vacuum shelf drier without further heat damage. The samples then were canned in nitrogen for later measure of heat damage. To determine the course of drying, weight losses in the vacuum drier were carefully measured, and the moisture contents of the vacuum-dried samples were later determined.

To insure that the results would be comparable with those of samples heat damaged at constant moisture level, these drying runs were performed in the 15-day period in which the constant-moisture-content samples were prepared. A thermometer calibrated by the U. S. Bureau of Standards was used in calibrating the thermocouples and the thermometers in the cabinet drier and in the water baths in which potato samples were heat damaged.

Moisture determination. The 40-hour vacuum oven method of Makower, Chastain, and Nielsen *(9)* was used for moisture determinations. This method is used because it gives approximately the true moisture content *(9)*; it should be emphasized that the results are about 2% higher than those of the commonly used 6-hour vacuum oven method of Quartermaster Corps specifications *(14)*.

Soluble color determination. A new soluble-color measurement was developed for the degree of browning, necessitated by the fact that the structure of vacuum-dried samples was highly porous and gave a fine powder on grinding. With the former procedure *(5)*, in which the color is extracted by shaking with 55% ethanol, it was found that the very fine powder from the vacuum-dried material yielded more color than did the coarser powder from the more dense air-dried samples. Absorption spectra indicated that the additional color was probably due to carotenoids. In the new procedure the potato powder is not contacted by organic solvent, and the difficulty is avoided.

The procedure is as follows: The sample is ground through a 2-mm. screen. A 20-g. portion is extracted with 200 ml. of 2% acetic acid solution in a 500-ml. Erlenmeyer flask which is swirled at the beginning, middle, and end of a 1-hour period. The slurry is filtered through a coarse filter paper, preferably fluted. An aliquot of the filtrate is mixed with an equal volume of acetone and is then filtered twice through a Whatman No. 3 filter paper, with precautions previously described *(5)* to prevent loss of solvent. Care is necessary to insure that the powder does not form a dense clump that does not resuspend on swirling. If clumping occurs, the extraction may be incomplete; serious error can thus occur, particularly if extraction flasks are small (for example, if 250- instead of 500-ml. flasks are used).

The extracted color is measured at 420 mμ with the solution in a 2-cm. cell, and the results are expressed in terms of optical density, $E^{5\%}_{2\text{ cm., }420\text{ m}\mu}$. Measured at 420 mμ, an optical density increase of 0.100 corresponds approximately to the arbitrary "limit of palatability" *(8)*.

RESULTS

Constant-moisture rates of heat damage. Plots of optical density *vs.* time were approximately straight lines (pseudo zero order, Figure 1).[b] This linear relation for nonsulfited dehydrated vegetables was previously reported by Legault *et al. (7)*. The slopes of these lines are taken as the rates of browning, in optical density units per hour. These "observed rates of browning" are given in Table 2, together with "smoothed rates" from Arrhenius-type plots of the logarithm of the observed rate vs. the reciprocal of the absolute temperature (Figure 2).[c] The

[b] Deviations from the straight-line relation have been observed by the authors with some lots of dehydrated nonsulfited white potato. These deviations will be discussed in a later publication.

[c] Legault *et al. (7, 8)* reported previously that Arrhenius-type plots can be used for correlation of rates of browning of dehydrated vegetables during storage. Stadtman *et al. (12)* found the relation applicable to the browning of dried apricots, and Mohammad *et al. (10)* found it applicable to the browning of solutions of glucose and bovine serum albumin.

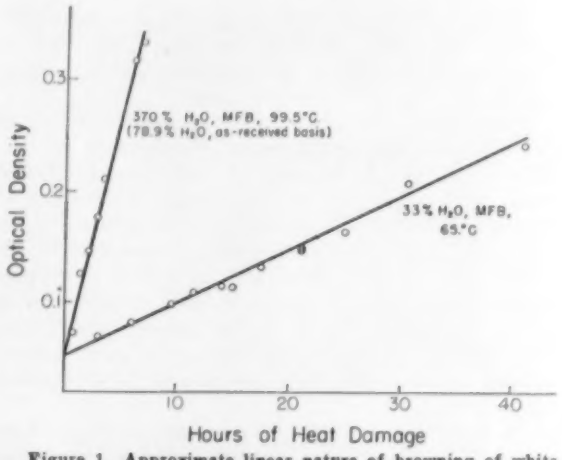


Figure 1. Approximate linear nature of browning of white potato half-dice packed in air.

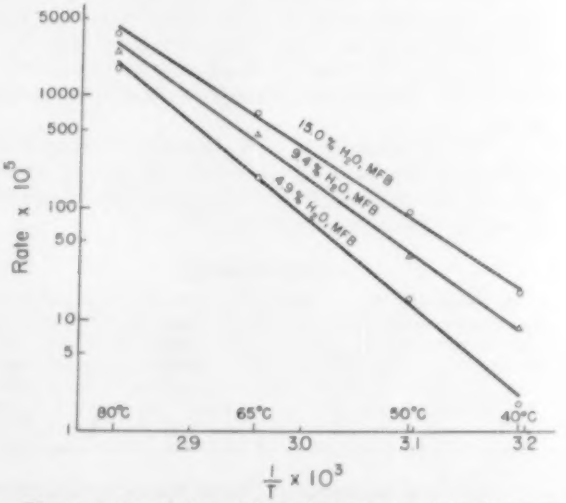


Figure 2. Correlation of browning rates by Arrhenius-type plot of logarithm of the rate vs. the reciprocal of the absolute temperature.

TABLE 2

Rates of nonenzymatic browning[1] at constant temperatures and constant moisture levels — Idaho Russet Burbank potatoes containing 1.1% reducing sugars, MFB, heat-damaged in air and in vacuum

H_2O MFB, %	Air 40° C.		Air 50° C.		Air 65° C.		Vacuum 65° C.	Air 80° C.		Air 99.5° C.	
	Obs.	Smoothed	Obs.	Smoothed	Obs.	Smoothed	Obs.	Obs.	Smoothed	Obs.	Smoothed
370	.....	.....	....	....	88	95	26	580	510	4200	4400
110	.....	.....	36	38	210	204	95	1000	1000	.....	.....
33	.....	.....	76	79	455	435	200	1840	2040	.....	.....
15.0	17	20	90	83	670	600	510	3450	3600	.....	.....
9.4	8.1	8.0	37	40	450	370	410	2400	2800	.....	.....
4.9	1.7	2.1	16	13	181	180	185	1700	1850	.....	.....

[1] Rates are $\Delta E \frac{5\%}{2\text{ cm., }420\text{ m}\mu/\text{hour}}$. Smoothed rates were read from Arrhenius plots of the type shown in Figure 2.

fit of the data to the Arrhenius relation is good. Although the browning rates cover a range of 2,000-fold, with a 1,000-fold range within one of the moisture series (the 4.9% series), it may be noted in Table 2 that in most instances the difference between the observed and smoothed values is no more than about 15% of the smoothed value (average 9%).

The smoothed-curve rates of browning are plotted in Figure 3. This chart is the form in which the constant-moisture rates of browning are used in estimating browning during drying. The chart shows that for potatoes heat-damaged at constant moisture, browning is most rapid at a moisture content of about 15 to 20%, MFB (13 to 17% on an "as-received" basis). Similar maxima have been observed with other lots of white potato heat damaged at constant moisture content and constant temperature.

Figure 3 and Table 2 also show that rate of browning increases rapidly with increasing temperature. The Q_{10} values (increase in rate with each 10° C. (18° F.) increase in temperature) range from 3- to 6.5-fold. The effect of temperature decreases with increasing moisture content. Table 3 shows the corresponding decrease in apparent activation energies with

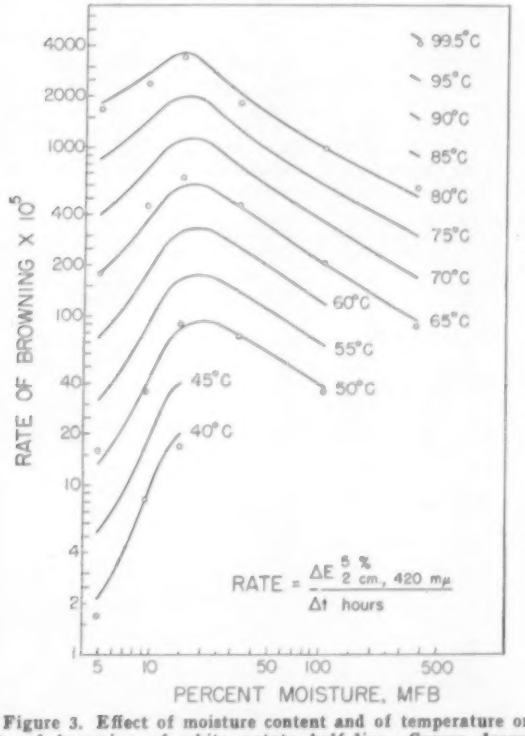


Figure 3. Effect of moisture content and of temperature on rate of browning of white potato half-dice. Curves drawn through points read from Arrhenius-type plots such as those shown in Figure 2.

TABLE 3

Effect of moisture content on apparent activation energy for nonenzymatic browning of white potato dice in air

H_2O, MFB, %	Apparent activation energy, kg.-cal./mole
370	26
110	25
33	25
15.0	28
9.4	32
4.9	37

increase in the moisture content. The activation energies of 37 and 32 kg.-cal./mole for the samples of 4.6 and 9.4% moisture are in reasonable agreement with values of 40 and 36 kg.-cal. obtained by Legault *et al. (7)* for white potatoes at 5.3 and 8.9% moisture, respectively.

Vacuum packing had no apparent effect on rate of browning at low moisture content (samples damaged at 65° C., Table 2). This is in accord with observations by Tomkins *et al. (13)*, Continental Can Co. research staff *(3)*, Burton *(2)*, and Legault *et al. (7)* on the browning of dehydrated potato during storage. But at high moisture content, vacuum packing reduced the rate of browning to as little as one-fourth the rate in air. Similar results were obtained with a lot of Katahdin potatoes grown in Maine.

Heat damage during cabinet drying. Data on browning, moisture content, and piece temperature of samples heat-damaged during cabinet drying are shown in Table 4. Figure 4 shows plots of the browning for these runs. Curves of this same shape have been obtained with other lots of potatoes on cabinet drying. It will be noted that there is no tendency in these plots for the browning to become slower at the end of drying. Such a ten-

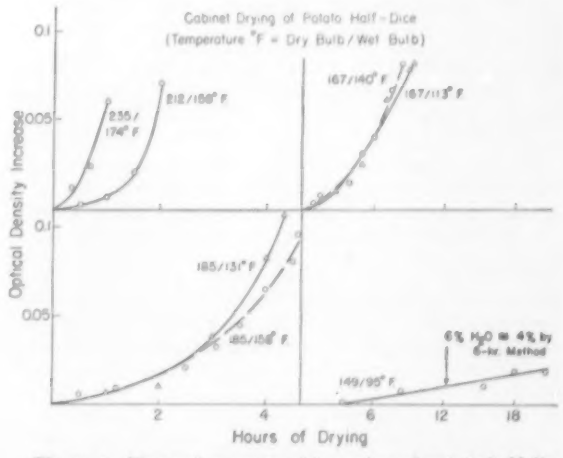


Figure 4. Observed amounts of browning of potato half-dice during cabinet drying at air temperatures ranging from 149° to 235° F. (65° to 113° C.).

TABLE 4

Observed and estimated degrees of browning during drying of Idaho Russet Burbank potato half-dice (⅜ x ⅜ x 3/16-inch before drying)—reducing sugar content, 1.1%, MFB

Air conditions			Drying time	Moisture content	Piece temperature	Browning [1] $\Delta E^{5\%}_{2\text{ cm., }420\text{ m}\mu}$	
Temperature		Velocity					
Dry bulb	Wet bulb					Obs.	Est.
° F.	° F.	fpm.	hrs.	%	° F.		
149	95	1350	0	370	70	.000	.000
			2	30	146	.000	.001
			4	9.5	148	.002	.010
			8	6.8	149	.006	.024
			16	5.6	149	.015	.040
			24	5.0	149	.024	.058
			36	4.3	149	.040	.078
149	122	1150	2	75	134	.002	.001
			4	17.5	149	.005	.010
			8	9.6	149	.012	.035
			16	8.7	149	.030	.070
167	113	1150	2	20	163	.004	.006
			4	8.5	167	.022	.038
			8	6.2	167	.065	.080
			16	5.0	167	.190	.150
167	140	1150	2	60	151	.008	.002
			4	14.5	166	.020	.026
			8	8.3	167	.075	.085
185	131	1150	1	75	159	.006	.000
			2	17	182	.016	.024
			4	8.0	185	.080	.130
185	158	625	1	170	161	.006	.002
			2	40	170	.016	.008
			4	13.0	185	.060	.078
			6	9.0	185	.200	.180
212	158	750	0.5	180	165	.002	.001
			1.0	52	188	.006	.008
			1.5	21	203	.020	.042
			2.0	12.2	210	.070	.170
235	174	400	0.5	175	178	.015	.004
			1.0	55	200	.060	.018

[1] Browning of $\Delta E^{5\%}_{2\text{ cm. }420\text{ m}\mu} = 0.100$ corresponds to arbitrary limit of palatability.

dency would be expected from the constant-moisture browning rates.

To determine the accuracy with which the constant-moisture rates can be used to predict heat damage during drying, estimates were made with the constant-moisture data of Figure 3, together with the piece-temperature and moisture-content data obtained in the cabinet drying runs. The values are recorded in Table 4 and illustrated, for one typical case, in Figure 5. Agreement of the estimated and observed browning values is approximate but not exact.[4] Comparisons such as those in Table 5 (see next section) show that the relative effects of variations in dehydrator design and operation can be estimated with reasonable accuracy from the constant-moisture rates. It therefore appears that the constant-moisture rates can be useful in dehydrator design.

[4] Moisture gradients within the drying piece may be a major cause of difference between observed and estimated values. The moisture content at the center of the drying piece will be higher than the average of the piece as a whole, perhaps enough higher to be in the "critical moisture region" of 10 to 25%. Browning tends to occur primarily at the center of the piece. Central browning may in part be the result of migration of soluble constituents (including browning reactants) to the center. Van Arsdel *(15)* has suggested that such migration may occur under the influence of the gradients that exist during drying. A part of the difference may also have been caused by error in piece-temperature measurement. Piece temperatures estimated by the procedure proposed by Van Arsdel [reported by Kilpatrick, Lowe, and Van Arsdel *(6)*] were a little lower than those observed for the early stages of drying, but not enough lower to change greatly the estimated amount of heat damage.

In addition, the cabinet-drying results (Table 4 and Figure 4) may be of value to operators for quick estimation of relative effects of changes in operating conditions. The constant-moisture rates and the cabinet-drying results may also have qualitative application in the dehydration of various vegetable and fruit products other than potato.

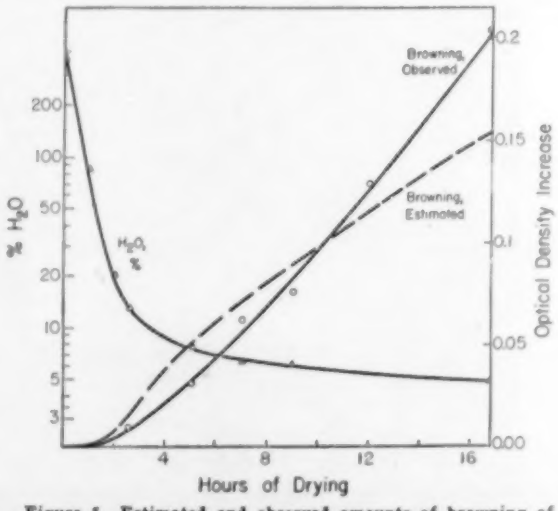


Figure 5. Estimated and observed amounts of browning of white potato during cabinet drying. Air temperature: 167° F. dry bulb, 113° F. wet bulb (75° and 45° C., respectively).

TABLE 5

Cabinet drying—moisture levels and drying times at which equal small amounts of browning had occurred on drying of white potato half-dice at various air temperatures, based on (a) observed amount of browning, and (b) estimated amount of browning

Air temperature		Moisture content and drying times for browning of 0.010-optical-density units			
		Based on *observed* amount of browning		Based on *estimated* amount of browning	
Dry bulb	Wet bulb	H_2O	Hours drying	H_2O	Hours drying
° F.	° F.	%		%	
149	95	6.2	11	10	4.0
167	113	12	2.7	17	2.2
185	131	22	1.6	25	1.6
212	158	42	1.1	52	1.0

DISCUSSION

Dehydrator design. The amounts of heat damage estimated and observed under the various drying conditions lead to interesting speculations regarding dehydrator design and operation.

From the constant-moisture results, the maxima in the plot of browning rate *vs.* moisture content (Figure 3) would at first seem to suggest that browning could be minimized by use of the lowest possible air temperature in passing through the moisture region from about 25 to 10% moisture, and that use of low air temperature at the end of drying would be less important.

However, as mentioned above and as shown in Figure 4 and Table 4, the cabinet-drying results show that under actual drying conditions, browning is at least as fast at the end of drying as at the intermediate moisture levels. When plotted against moisture content, both the observed and the estimated data show that browning is much more severe at the end of drying than at slightly higher moisture levels (Figure 6). This means that in tunnel-type driers high air temperatures can be better tolerated at intermediate moisture contents than at the final moisture values.

It also means that the capacity of a counterflow tunnel could be substantially increased if the product could be discharged at slightly higher moisture level than is common at present. The higher capacity would result from the higher permissible temperature of the inlet air. The data in Table 5 suggest in qualitative fashion the increase in air temperature that might be allowable if the product were discharged at various higher moisture levels. This table, based on the cabinet-drying runs of the present study, shows for various air temperatures the approximate drying time and the approximate moisture content the product would have had if in each run it had been discharged from the drier when a given small amount of browning had occurred. The estimated browning data indicate higher product moisture levels than do the observed data (for the same amount of browning at a given temperature), but both suggest that in the low-moisture range an increase in temperature of 18° F. would have been possible with each 6 to 10% increase in the moisture content at which the product was discharged from the cabinet drier. It would be reasonable to expect that qualitatively similar temperature increases would be possible for counter-flow tunnel driers.

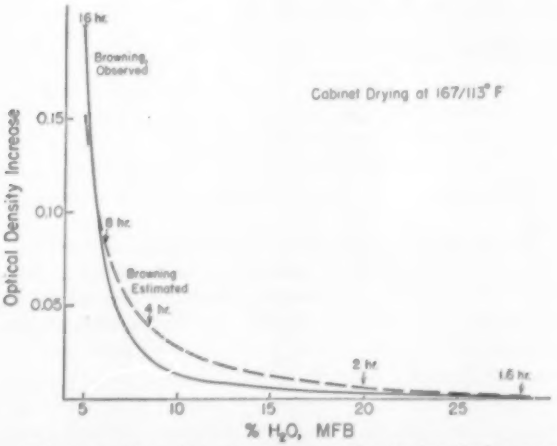


Figure 6. Browning of potato half-dice during drying as a function of the product moisture content. Air temperature: 167° F. dry bulb, 113° F. wet bulb (75° and 45° C., respectively).

Before the advantages of discharging from the tunnels at high moisture level can be realized, it will be necessary to have an adequate method of completing the drying from the higher moisture content. Finishing bins, either batch or continuous, offer some promise for this purpose, although considerable study will be required for determination of optimum design and operating conditions.

Another interesting aspect of the results (Figure 4) is that relatively little browning occurred in the dice dried at 149° F. and 95° F. wet-bulb temperature, even when dried below a moisture level of 6% (corresponding to approximately 4% by the 6-hour method). This suggests that under suitable conditions potato dice might be bin-dried without heat damage to moisture levels low enough to give excellent storage stability with respect to browning. It has been shown (Legault *et al. (8)*, also Hendel and Silveira, unpublished) that at this moisture level dehydrated dice have very good resistance to browning during storage.

Results of the present investigation thus suggest that study of finishing drying at both high and low moisture contents would be well warranted from the standpoints of (a) possible increase in plant drying capacity and (b) improved storage stability of dehydrated product.

SUMMARY

To obtain information for use in dehydrator design, rates of nonenzymatic browning have been measured for white potato half-dice held at a series of constant moisture levels and constant temperatures covering the range encountered during dehydration. Browning during dehydration was also measured for a series of cabinet-drying runs.

The data show that for constant-moisture heat damage the rate of browning is most rapid at a moisture content of about 15 to 20%. In contrast, no such maximum occurs in samples heat damaged under actual drying conditions, browning being at least as fast at the end of drying as at slightly higher moisture levels.

The rate of browning increases rapidly with increasing temperature, about 3- to 6.5-fold with each 10° C. (18° F.) rise for constant-moisture browning between 40° C. (104° F.) and 100° C. (212° F.). It follows the Arrhenius relation, i.e., plots of the logarithm of the rate vs. the reciprocal of the absolute temperature are straight lines. The apparent activation energies ranged from 25 to 37 kg.-cal./mole, increasing with decreasing moisture content below about 20%.

Vacuum-packing reduced rate of browning of high-moisture samples to as little as about one-fourth that in air, for the constant-moisture samples, but had no apparent effect on drier materials (below about 15% moisture).

The constant-moisture browning rates can be used to estimate the effects of various operating and design variables. The cabinet-drying results may also be useful in dehydrator design. It is believed the results may have qualitative application in the dehydration of a variety of fruit and vegetable products other than potato.

Acknowledgment

The authors are pleased to acknowledge the suggestions and encouragement of H. K. Burr, H. S. Olcott, and W. B. Van Arsdel of the Western Utilization Research Branch and of R. R. Legault, formerly of this Branch and now at Washington State College.

LITERATURE CITED

1. Anonymous. Dry rate nomographs. VII. White potato half cubes. AIC-31-VII. Western Regional Research Laboratory (Albany, Calif.), U. S. Department of Agriculture (March, 1945).
2. Burton, W. G. Mashed potato powder. III. High temperature browning of mashed-potato powder. *J. Soc. Chem. Inds.*, **64**, 215 (1945).
3. Continental Can Co., Research Staff. New facts about packaging and storing dehydrated foods. *Food Inds.*, **16**, 991 (1944).
4. Denny, F. E., and Thornton, N. C. The third year's results on storage of potato tubers in relation to sugar content and color of potato chips. *Contrib. Boyce Thompson Inst.*, **12**, 405 (1942).
5. Hendel, C. E., Bailey, G. F., and Taylor, D. H. Measurement of nonenzymatic browning in dehydrated vegetables during storage. *Food Technol.*, **4**, 344 (1950).
6. Kilpatrick, P. W., Lowe, E., and Van Arsdel, W. B. Tunnel dehydrators for fruits and vegetables. *Advances in Food Research, VI.* Academic Press, Inc., New York.
7. Legault, R. R., Talburt, W. F., Mylne, A. M., and Bryan, L. A. Browning of dehydrated vegetables during storage. *Ind. Eng. Chem.*, **39**, 1294 (1947).
8. Legault, R. R., Hendel, C. E., Talburt, W. F., and Pool, M. F. Browning of dehydrated sulfited vegetables during storage. *Food Technol.*, **5**, 417 (1951).
9. Makower, B., Chastain, S. M., and Nielsen, E. Moisture determination in dehydrated vegetables. Vacuum oven method. *Ind. Eng. Chem.*, **38**, 725 (1946).
10. Mohammad, A., Fraenkel-Conrat, H., and Olcott, H. S. The "browning" reaction of proteins with glucose. *Arch. Biochem.*, **24**, 157 (1949).
11. Ross, A. F., Hilborn, M. T., Jenness, L. C., and Bartlett, E. M. Selecting and storing potatoes to avoid darkening. *Food Inds.*, **18**, 1011 (1946).
12. Stadtman, E. R., Barker, H. A., Haas, V. A., and Mrak, E. M. Studies on the storage of dried fruit. III. The influence of temperature on the deterioration of dried apricots. *Ind. Eng. Chem.*, **38**, 541 (1945).
13. Tomkins, R. G., Mapson, L. W., Allen, R. J. L., Wager, H. G., and Barker, J. The drying of vegetables. III. The storage of dried vegetables. *J. Soc. Chem. Ind.*, **63**, 225 (1944).
14. U. S. Military Specification, Potatoes, White, Dehydrated, MIL-P-10733A (Dec., 12, 1950).
15. Van Arsdel, W. B. Principles of the drying process with special reference to vegetable dehydration (processed). Western Regional Research Laboratory (Albany, Calif.), U. S. Bur. Agr. and Indus. Chem., AIC-300 (Jan., 1951).
16. Wright, R. C., Peacock, W. M., Whiteman, T. M., and Whiteman, E. F. The cooking quality, palatability, and carbohydrate composition of potatoes as influenced by storage temperatures. U. S. Dept. Agr. Tech. *Bull. 507* (1936).

The Effects of Low Methoxyl Pectin and Calcium Salts on the Drained Weight and Calcium Content of Processed Raspberries[a]

ARTHUR P. SIDWELL[b] AND ROBERT F. CAIN[c]

Department of Food Technology, Oregon State College, Corvallis, Oregon

(Manuscript received April 18, 1955)

The effects of calcium salts and mode of their addition, when used alone or in combination with low methoxyl pectin, on the drained weight of canned and frozen Washington variety red raspberries were investigated. Results show calcium salts to generally decrease the drained weight and low methoxyl pectin to generally increase the drained weight. The calcium content of treated berries was found to be related to the mode of addition of the calcium salts used.

The grading factor, "Character of Fruit," in the U. S. Grade Standards for processed red raspberries considers the degree of disintegration of the berries to be of significance in determining the final grade of the product. Also, the canned product must meet a minimum drained weight requirement. Means of preventing the disintegration of these berries when processed would be reflected in higher pack-out return and would assist in maintaining the grade of the product.

The fact that certain calcium salts aid in the retention of the wholeness of fruit, as demonstrated by in-

[a] Technical Paper No. 904, Oregon Agricultural Experiment Station.

[b] Research Assistant, Food Technology Department.

[c] Associate Food Technologist, Food Technology Department.

crease in drained weight, is well known in the case of Solanaceous fruit, as pointed out by Kertesz *et al. (5)* and Powers *et al. (6)*. The use of calcium as a permitted optional additive for increasing the wholeness of tomatoes has been recognized in the Standards for Identity for this product *(3)*. Since about 1940, the use of pectinates has been suggested by certain workers as a material which could be used alone or in combination with calcium to increase the drained weight of certain products.

Baker *(1)*, in working with low methoxyl pectin and calcium chloride to increase the drained weight of frozen strawberries, found that a 2% solution of cold low methoxyl pectin (hereafter abbreviated LMP) reduced the loss of juice from thawed strawberries by about 33%. He was not able to demonstrate that calcium alone or in combination with LMP was as effective as LMP when used alone. Wegener, Baer, and Rodgers *(7)* reported that in the Tennessee Supreme variety of strawberry, packed as a frozen product in sirup, LMP, when added to the fruit at levels of 0.15-0.20%, was very effective in increasing the drained weight. They found that LMP at these levels was as effective as algin extractives when used at levels of 0.30-0.40%. Earlier work by Grab *et al. (4)* reported that LMP was more effective in increasing the drained weight of strawberries when added to the sirup of a 3 + 1-60% sucrose sirup pack than when added to a dry pack. In their use of calcium chloride as a 1% dip, for one minute, the results were less promising than when LMP was used alone. They also reported that LMP in concentration greater than 0.30% started gelling when added to the sirup and that the optimum concentration appeared to be between 0.20 and 0.30% by weight of the fruit.

Erikson and Boyden *(2)* added calcium chloride at concentrations of 0.50, 0.70, and 0.90% by weight of fruit to Latham and Cuthbert raspberries before canning. Using the oven-method of canning, they reported a slight improvement in drained weight of the fruit over that of the control. Sugar appeared to act as a depressant to this effect of calcium. Although the judges usually noted increased firmness, it did not follow that these results were consistent with increased drained weight.

This investigation was initiated to determine the effectiveness of added calcium salts alone and in combination with LMP in decreasing the disintegration of dessert packs of canned and frozen Washington variety raspberries, using drained weight as the criterion. The calcium determinations were made to show the calcium uptake in berries either dipped in calcium solutions or packed with sirups containing calcium salts. The 40% sucrose sirup was selected as it is widely used in the Northwest for packs of this type.

METHODS AND MATERIALS

A. Sample preparation

Variety: Washington red raspberries.

Packages: 301 x 411 berry enamel cans, filled to 10 ounces.

Sirup: 40% sucrose, using 5 oz. (150 mls. per can), for frozen lots. In lots canned (heat processed) 215 mls. of sirup were added to each can.

Heat process: Berries heat exhausted to 180° F. (82° C.) center temperature in 7 minutes, then processed for 7 minutes at 211° F. (99.5° C.).

Freezing technique: Frozen at —20° F. (—29° C.) left overnight, then transferred to —5° F. (—20.5° C.) storage.

In the first experiment (Tables 1, 2, 5) on the effects of LMP and calcium lactate, a 3 x 7 x 2 factorial design was used. The 3 calcium treatments were (a) no calcium; (b) berries dipped for 1 minute in 2.78% calcium lactate solution, before filling and (c) berries siruped with 40% sucrose solution containing 0.00484 g. of calcium lactate per ml. of sirup. The dipping solution in treatment (b) was equivalent to 1% calcium chloride solution (anhydrous basis). The calcium treatments in the sirup were designed to furnish a maximum content of 0.07% anhydrous calcium chloride, on the net weight basis.

The seven LMP[4] treatments were (a) no LMP with b, c, d, e, f, g, being 0.05%, 0.10%, 0.15%, 0.20%, 0.25% and 0.30% of LMP respectively. The LMP was dissolved in the sirup, using a Waring blender. In combinations in which it was to be added to the sirup, calcium lactate was added after the LMP had been dissolved in the sirup.

In the second experiment (Tables 3, 4, 6) the effects of LMP and the calcium salts, citrate and lactate, were tested. A 5 x 4 x 3 factorial design was used. The 5 calcium treatments were: (a) no calcium; (b) berries dipped for 1 minute in 1% calcium chloride solution (anhydrous basis); (c) berries dipped for 1

[4] The material used was LMP No. 466, supplied by the California Fruit Growers Exchange.

TABLE 1

The effects of calcium lactate and of low methoxyl pectin on the percentage drained weight of canned raspberries

Calcium lactate treatment (below)	Percent concentration of LMP							Means of calcium treatments (below)
	0.00 %	0.05 %	0.10 %	0.15 %	0.20 %	0.25 %	0.30 %	
	(Means of Individual Treatments)							
None	41.4	43.9	47.0	44.8	47.7	47.0	53.0	46.37
Calcium lactate in sirup	44.0	45.9	47.1	50.2	51.5	53.8	55.0	49.57
Calcium lactate dip	41.4	40.8	47.4	48.0	49.8	50.9	51.7	47.14
LMP treatment means	42.28	43.52	47.12	47.65	49.65	50.40	52.23	

L.S.D. (between calcium means): 0.05-1.53; 0.01-2.06.
L.S.D. (between LMP means): 0.05-2.29; 0.01-3.08.
Interactive effects not significant.

TABLE 2

The effects of calcium lactate and of low methoxyl pectin on the percentage drained weight of frozen raspberries

Calcium lactate treatment (below)	Percent concentration of LMP							Means of calcium treatments (below)
	0.00 %	0.05 %	0.10 %	0.15 %	0.20 %	0.25 %	0.30 %	
	(Means of Individual Treatments)							
None	52.0	54.8	54.6	60.4	63.9	68.4	69.6	60.53
Calcium lactate in sirup	51.1	53.3	55.3	56.8	55.9	59.4	62.2	56.27
Calcium lactate dip	51.1	51.6	54.9	54.5	64.6	65.0	66.3	58.28
Means of LMP treatments	51.4	53.2	54.9	57.2	61.4	64.3	66.0	

L.S.D. (between calcium treatment means): 0.05-2.90; 0.01-4.06.
L.S.D. (between LMP treatment means): 0.05-4.44; 0.01-6.23.
Interactive effects significant at 0.01 level.

TABLE 3

The effects of citrate and chloride of calcium and of low methoxyl pectin on the percentage drained weight of canned raspberries

Calcium treatments (below)	Percent concentration of LMP					Means of calcium treatments (below)
	0.00 %	0.05 %	0.10 %	0.15 %	0.20 %	
	(Means of Individual Treatments)					
None	48.1	49.4	48.0	50.8	53.2	49.90
Calcium chloride dip	49.3	51.7	51.1	54.7	58.1	52.99
Calcium citrate dip	51.1	50.7	53.6	54.2	53.8	52.69
Calcium chloride in sirup	46.7	49.0	50.3	53.1	55.8	50.97
Calcium citrate in sirup	46.6	48.1	52.3	42.9	47.2	47.62
Means of LMP treatments	48.38	49.77	51.06	51.33	53.63	

L.S.D. (between means of calcium treatments or means of LMP treatments): 0.05-2.47; 0.01-3.28.
Interactive effects not significant.

TABLE 4

The effects of citrate and chloride of calcium and of low methoxyl pectin on the percentage drained weight of frozen raspberries

Calcium treatments (below)	Percent concentration of LMP					Means of calcium treatments (below)
	0.00 %	0.05 %	0.10 %	0.15 %	0.20 %	
	(Means of Individual Treatments)					
None	56.6	60.4	62.0	66.5	68.8	62.86
Calcium chloride dip	57.4	57.3	59.0	63.3	63.1	60.03
Calcium citrate dip	54.5	57.8	60.9	64.3	67.0	60.92
Calcium chloride in sirup	55.0	56.4	57.5	59.0	61.3	57.83
Calcium citrate in sirup	54.8	56.3	58.9	60.1	61.8	58.39
Means of LMP treatments	55.67	57.65	59.67	62.63	64.41	

L.S.D. (between means of calcium treatments or means of LMP treatments): 0.05-1.43; 0.01-1.91.
Interactive effects not significant.

minute in 0.25% calcium citrate solution; (d) berries siruped with 40% sucrose solution containing 0.00184 g. of calcium chloride (anhydrous basis) per ml. of sirup and (e) berries siruped with 40% sucrose solution containing 0.00305 g. of calcium citrate per ml. of sirup. These sirups contained approximately the same amount of calcium that was present in the calcium lactate sirup.

Calcium compounds when added to sirups containing LMP caused gelling of the sirups to such an extent that they could not be handled in sirup lines or in conventional siruping operations.

B. Thawing of frozen samples. Berries were taken from —5° F. (—20.5° C.) storage and placed at 34° F. (10° C.) overnight. They were then thawed in cool running water for 5 hours before opening. Temperature range of all samples was 57° F. (14° C.) to 62° F. (17° C.) when opened.

C. Determination of drained weight. Berries were drained on a standard 8 x 8 mesh draining screen for 2 minutes, then weighed and the appropriate calculations made.

D. Determination of calcium. Approximately 15 g. of berry solids, remaining on the screen from the drained weight determinations, was vacuum dried for 24 hours at 158° F. (70° C.) then ashed at 932° F. (500° C.) for 16 hours. The ash was moistened with water and 5 ml. concentrated hydrochloric acid was added. This was boiled to dryness, re-moistened with water and 3 ml. of concentrated hydrochloric acid added, and then boiled to dryness again. The treated ash was taken up in 2 ml. of concentrated nitric acid, diluted to 50 ml. with water, and allowed to stand 24 hours before filtering to remove silica.

Determinations were made using the Beckman flame photometer attached to a Beckman DU spectrophotometer. Readings were taken at 554 mμ. Hydrogen was used as fuel. The standards included the average amounts of soduim, magnesium, potassium and phosphorus found in preliminary tests on the samples. A didymium filter was also used to minimize interference from the sodium band at 589 millimicrons.

Evaluation of the data: Conventional methods of analysis of variance were used.

OBSERVATIONS AND DISCUSSION OF RESULTS

Results of this experiment permit the following discussion with respect to the effects of LMP and various salts of calcium on the drained weight and calcium content of canned and frozen Washington raspberries.

Drained weight. The percentage drained weight of both canned and frozen Washington raspberries increased significantly with increasing increments of LMP added to the sirup regardless of the type of calcium salts used and the mode of their application (Tables 1 to 4).

The effects of calcium salts were to generally reduce the drained weight of frozen raspberries, though when calcium lactate was used the level of LMP had some effect on this reduction (Tables 2, 4). The use of calcium salts in the sirup caused greater reductions in drained weight than occurred when the berries were dipped in calcium solutions before siruping and freezing.

The effect of the addition of calcium salts on the drained weight of canned raspberries was not consistent. For example, in Table 1, the addition of calcium lactate to the sirup caused a significant increase in percentage

TABLE 5

The percentage[1] calcium content of frozen raspberries treated with low methoxyl pectin and with calcium lactate

Calcium treatments (below)	Percent concentration of LMP							Means of calcium treatments (below)
	0.00 %	0.05 %	0.10 %	0.15 %	0.20 %	0.25 %	0.30 %	
	(Means of Individual Treatments)							
None	0.0304	0.0268	0.0245	0.0268	0.0265	0.0294	0.0235	0.0268
Calcium lactate in sirup	0.0439	0.0433	0.0445	0.0421	0.0406	0.0394	0.0420	0.0424
Calcium lactate dip	0.0367	0.0390	0.0402	0.0356	0.0341	0.0330	0.0346	0.0362
Means of LMP treatments	0.0370	0.0367	0.0364	0.0348	0.0338	0.0339	0.0333	

L.S.D. (between calcium treatment means): 0.05-0.002; 0.01-0.003.
Differences between LMP treatment means are not significant.
Interactive effects not significant.
[1] Wet weight basis.

TABLE 6

The percentage[1] calcium content of frozen raspberries treated with low methoxyl pectin and citrate and chloride of calcium

Calcium treatments (below)	Percent concentration of LMP				Means of calcium treatments (below)
	0.05 %	0.10 %	0.15 %	0.20 %	
	(Means of Individual Treatments)[2]				
None	0.0337	0.0371	0.0318	0.0267	0.0323
Calcium chloride dip	0.0437	0.0468	0.0462	0.0436	0.0450
Calcium citrate dip	0.0352	0.0385	0.0368	0.0353	0.0365
Calcium chloride in sirup	0.0486	0.0465	0.0445	0.0462	0.0464
Calcium citrate in sirup	0.0463	0.0459	0.0491	0.0489	0.0475
Means of LMP treatments	0.0415	0.0430	0.0417	0.0401	

L.S.D. (between calcium treatment means): 0.05-0.0037; 0.01-0.0052.
Difference between LMP treatment means are not significant.
Interactive effects significant at 0.05 level.
[1] Wet weight basis.
[2] No data presented for 0.00% LMP column. Loss of sample in 2 treatments in this column occurred.

drained weight over that of the control. However, no increase in drained weight was obtained when the berries were dipped in a solution of calcium lactate prior to canning. In Table 3, it can be noted that a significant increase in drained weight of canned raspberries occurred when citrate and chloride of calcium was added by the dip method. When these salts were added in the sirup of canned raspberries, variable results were obtained. The addition of calcium citrate caused a significant reduction of drained weight, whereas the mean drained weight of the calcium chloride in sirup treatments was not significantly different from the control.

As was noted by Erikson and Boyden *(2)* the drained weight did not necessarily correlate with the appearance of solidity.

Calcium content of raspberry solids. The percentage calcium content of the raspberry solids was significantly increased by calcium treatment, either as dip or by direct addition (Tables 5 and 6). Dipping in calcium chloride solution resulted in as high a percentage calcium as did direct addition of that salt (Table 6). This was not true in the cases of lactate (Table 5) and citrate of calcium (Table 6).

The natural calcium content of the untreated berries was found to be higher than that found effective in the firming of tomatoes, which is 0.07% calculated as anhydrous calcium chloride *(3, 5)*. This may have been of significance in respect to the generally negative results had from further additions of calcium salts.

GENERAL OBSERVATIONS

The solidity and sheen of the canned berries was generally improved by the treatments. However, the sirup was gelatinized in some cases. These included treatments of (a) 0.25% and 0.30% LMP and calcium lactate dip and (b) 0.20% LMP and calcium chloride dip.

The solidity and sheen of the frozen berries was improved by the treatments. Increased gelatinization was noted with increased treatment with LMP.

Differences in flavor of the canned berries were also noted. An objectionably bitter flavor was noted in berries to which calcium salts had been added in the sirup. This was not noted in the lots dipped in citrate and chloride of calcium, but was objectionable in lots dipped in calcium lactate. Effects of calcium treatments on flavor of frozen berries were not noticeable.

Acknowledgments

The technical assistance of Miss Ingrid Hellsten and of Mr. John Kitson is gratefully acknowledged. The California Fruit Growers Exchange supplied the LMP used.

LITERATURE CITED

1. Baker, G. L. Pectin as an aid in freezing fruit. I. Its application in the freezing preservation of strawberries. *Food Inds.*, **13** (1), 55 (1941).
2. Erikson, S. E., and Boyden, R. E. The effect of calcium chloride on the firmness of some canned products and on their content of ascorbic acid. Kentucky Agr. Exp. Sta. *Bull. 511* (1947).
3. Federal Security Agency, Food and Drug Administration. Promulgation of an amendment to the regulation establishing a standard of identity for canned tomatoes. *Federal Register*, 5,2282 (1940).
4. Grab, E. B. Jr., Wegener, J. B., and Baer, B. H. Firming strawberres before freezing. *Food Packer*, **29** (12), 39 (1948).
5. Kertesz, Z. I., Tolman, T. G., Loconti, J. D., and Ruyle, E. H. New York State Agr. Exp. Sta. *Tech. Bull. 252* (1940).
6. Powers, J. J., Morse, R. E., Sane, Ruth H., and Mills, W. C. Acidification and calcium firming of pimientos. *Food Technol.*, **4**, 485 (1950).
7. Wegener, John B., Baer, B. H., and Rodgers, P. D. Improving quality of frozen strawberries with added colloids. *Food Technol.*, **5**, 76 (1951).

Stability of Cucumber Peroxidase in Salt Stock Pickles During Fermentation, Curing, Storage, and Packing[a,b]

E. E. ANDERSON, R. A. LAMPI, AND W. B. ESSELEN

Department of Food Technology, University of Massachusetts, Amherst, Massachusetts

(Manuscript received May 26, 1955)

To learn whether or not peroxidase enzymes affect the quality of pickle products prepared from salt stock pickles, relative concentrations of peroxidase were determined at all stages of manufacture from fermentation to packing. Investigation was continued through varying periods of storage of the finished product. It appears, on the basis of results obtained in this study, that if peroxidase is a factor in loss of quality, its effect is exerted in the salting and curing tanks.

The influence of various enzymes on the quality of acid food products (pH of 4.5 or below) has received considerable attention during the past few years. More recently, the specific implication of peroxidase enzymes as causative factors for the development of off-flavors in pasteurized fresh pack pickles has been proved *(7)*. The problem of enzymic regeneration should also be considered inasmuch as Guyer and Holmquist *(2)* reported peroxidase regeneration in canned corn and peas processed by the high temperature—short-time method.

In view of these findings, it was considered desirable to learn whether peroxidase enzymes could also be responsible for the loss of quality in pickle products prepared from salt stock pickles. Consequently, at a commercial pickle plant, relative concentrations of peroxidase were determined in pickling cucumbers from the time they were received from the grower throughout the fermentation and curing, storage, freshening, and packing operations and after varying storage periods of the finished pickle products.

Review of literature. The necessity of blanching vegetables before freezing or dehydration has long been recognized. Tressler and Evers *(12)* after reviewing much of the work on frozen foods, emphasized the need for blanching. Blanching, they concluded, would destroy most of the peroxidase or catalase activity and thereby prevent off-flavors, and extend storage life.

Kaplan, Esselen, and Fellers *(5)* summarized the literature on the action of enzymes in the deterioration of acid foods. They observed that the thermal resistance of peroxidase in tomato juice and in pear and peach purées was relatively low compared to that of salt stock pickles. Peroxidase activity was not regenerated in salt stock pickles when the pickles were heated for the shortest time necessary to inactivate the peroxidase completely. Schwimmer *(11)*, however, reported peroxidase regeneration in turnips and cabbage.

In a study on the thermal destruction of peroxidase in pickles, Nebesky *et al. (9)* demonstrated that increased resistance to heat inactivation was associated with pickles containing increasing concentrations of peroxidase. They also observed that residual peroxidase concentrations remaining in fresh pack cucumber pickles immediately after processing were not destroyed during one year's storage at room temperature.

Joslyn and Bedford *(3)* and Joslyn and Marsh *(4)* concluded that off-flavor development was more closely associated with peroxidase than with catalase activity.

When sterilized fresh cucumber pureées were inoculated with different levels of a peroxidase concentrate prepared from pickles, Nebesky, Esselen, and Fellers *(8)* observed a flat or haylike flavor and aroma in the purées after 6 months' storage. Greater deterioration was found in the samples containing the higher levels of peroxidase concentrate. Examination of various commercial pickle products (i.e. Kosher style dills, processed dills, sweet mixed, mustard, midget, etc.) revealed no guaiacol peroxidase in any of the packs except the Kosher dills (fresh pack) and the processed dills. Labbee and Esselen *(7)* associated high off-flavor and off-odor levels in fresh pack pickles with high concentrations of peroxidase. Pickles containing active peroxidase developed more off-flavor when stored at 40° F. than packs stored at 70° or 100° F. These investigators attributed this response to probable enzyme inactivation at the higher storage temperatures.

Guyer and Holmquist *(2)* conducted an interesting study on peroxidase regeneration and its relationships to off-flavor development in canned peas. Peroxidase activity was not detectable in the peas either immediately after blanching or within 2 hours after processing. However, within 1 to 14 days after processing, peroxidase was regenerated.

In two instances, the peas had been given processes in an end-over-end agitating retort at 260° F., a temperature exceeding those commercially used (i.e. when based on F_0 of 8). All peroxidase concentrations found within 14 days after processing retained their activity at a constant level, from 0.1 to 0.4% of the original activity, over a 12-month storage period. Organoleptic analyses of the canned peas after 8 months of storage at room temperature revealed viny off-flavors in those pea packs retaining peroxidase activity.

EXPERIMENTAL

A near-by commercial pickle plant[c] supplied two 14,000-gallon wooden salting tanks; these were filled in July, 1953, with No. 1 size pickles (3½ to 4 inches long). Samples of 6 to 10 pickles and about a pint of brine were removed from each tank and tested for peroxidase activity at weekly intervals throughout the entire storage period (about 9½ months). In May, 1954, pickles in both tanks underwent the normal freshen-

[a] Presented before the Fifteenth Annual IFT Meeting, Columbus, Ohio, June 15, 1955.

[b] Contribution No. 1002, Massachusetts Agricultural Experiment Station, Amherst, Mass.

[c] Courtesy of D. M. Jewett Co., Inc., South Deerfield, Mass.

ing operations preparatory to being processed into finished pickle products. Samples were examined for peroxidase at the various stages of the freshening operations. The pickles were then made up into 5 different pickle products, i.e., dill chips, processed dill pickles, sour pickles, sweet mixed pickles, and processed kosher dills. Two cases (24 jars) of each pickle product were set aside to determine the peroxidase regeneration during storage.

Peroxidase activity was tested by the method proposed by Anderson *et al. (1)*—a modification of that suggested by Reddi, Esselen, and Fellers *(10)*. These investigators reported that of the 3 peroxidase substrates tested, i.e., guaiacol, o-phenylenediamine dihydrochloride (opda) and pyrogallol, opda was the most sensitive to colorimetric measurements.

As mentioned, on each sampling date at least 6 pickles as well as brine samples were taken from each tank. Composite 25-gram samples were then obtained from the whole pickles, which were comminuted in a Waring blender with a standard volume of distilled water. The same volume of distilled water was added to 25 ml. aliquots of the test brines to compare the relative concentrations of peroxidase in both media. Anderson *et al. (1)* had previously reported peroxidase concentrations to be greater in the brine of salt stock pickles than in the pickles themselves. Negative control samples were also prepared from both brine and pickle samples by boiling for 10 minutes in 125-ml. Erlenmeyer flasks containing a small amount of an antifoam agent.[4]

Upon completing the test, the colors developed in the samples were compared visually to a reference set of potassium dichromate color standards developed by Labbee *(6)* for this purpose (Table 1).

TABLE 1

Composition and color of potassium dichromate color standards

Standard	Composition		Color
No. 1	20 ml. distilled water		No color
No. 2	20 ml. distilled water plus	0.0005 g. K_2CrO_7	No color
No. 3		0.0010 g. K_2CrO_7	Very slight yellow tinge
No. 4		0.0025 g. K_2CrO_7	Definite yellow tinge
No. 5		0.0050 g. K_2CrO_7	Yellow
No. 6		0.0100 g. K_2CrO_7	Bright yellow
No. 7		0.0500 g. K_2CrO_7	Yellow orange
No. 8		0.1000 g. K_2CrO_7	Light orange
No. 9		0.5000 g. K_2CrO_7	Orange
No. 10		1.0000 g. K_2CrO_7	Orange brown

After storing the pickles as salt stock for 42 weeks, the manufacturer decided to process the contents of both tanks into various pickle products. Arrangements were made to withdraw samples of pickles throughout the various stages of the freshening process. Freshening involved transferral from the outside curing and holding tanks into smaller tanks in the freshening room where the pickles remained in fresh water for 12 to 18 hours. The water was then drained off, fresh water added, and the entire contents heated by steam to a temperature of approximately 160° F. The tanks were allowed to cool and remain undisturbed for about 24 hours. The pickles were then removed, sorted, and transferred into small tanks containing 12-degree brine until used in the packing room. No further heat treatment was given the particular salt stock products studied in the present investigations.

RESULTS AND DISCUSSION

A rapid and relatively continouus loss of peroxidase activity took place within the pickles throughout the first 23 weeks of storage (Figure 1). For the remaining 20 weeks the level of peroxidase activity remained quite constant.

Although peroxidase activity was not detectable in the brines during the 24 hours immediately after covering the tanks, after one week the brine had as much peroxidase activity as the pickles. From this point, the peroxidase activity in the brines tended to parallel that in the pickles. However, from the second through the 28th weeks, peroxidase concentrations in the brines of both tanks appeared slightly greater than those in the pickles. From the 28th through the 42nd week of storage little or no difference in peroxidase activity was detectable between the two media.

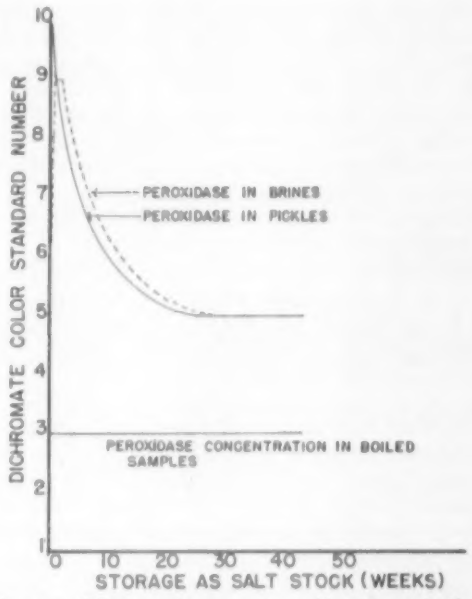

DICHROMATE COLOR STANDARD NUMBER
PEROXIDASE IN BRINES
PEROXIDASE IN PICKLES
PEROXIDASE CONCENTRATION IN BOILED SAMPLES
STORAGE AS SALT STOCK (WEEKS)

Figure 1. Effect of storage on peroxidase concentrations in salt stock pickles and brine.

After 7 weeks of curing and storage, the pH of the brines remained constant at pH 3.4.

As indicated previously, after 42 weeks of storage, the salt stock pickles were subjected to standard freshening operations preparatory to being packed. From the results (Table 2) it is apparent that the freshening operations further reduced the peroxidase concentration to a level which under the experimental conditions was indistinguishable from the negative control or cooked pickle samples.

It is not unlikely that the heating of the tank contents to 160° F. was the factor largely responsible for the apparent destruction of the residual peroxidase activity.

TABLE 2

Peroxidase concentrations in salt stock picles before and after freshening operations

Product	Color development[1]
Tank 42 (pickles after 1 week's storage)	Standard No. 9
Tank 42 (pickles after 42 weeks' storage)	Standard No. 5
Tank 43 (pickles after 42 weeks' storage)	Standard No. 5
Tanks 42 and 43 (pickles after 42 weeks' storage, boiled)	Standard No. 3
Tank 43 (pickles after 38 hours in freshening tank and 144 hours in transfer tank)	Standard No. 3
Tank 43 (pickles after 38 hours in freshening tank and 144 hours in transfer tank, boiled)	Standard No. 3
Negative Control (no pickles added)	Standard No. 3

[1] Intensity of peroxidase activity decreases with Standard Number (See Table 1).

[4] Dow Corning Antifoam A, Dow Corning Corp., Midland, Michigan.

For, although temperatures of 160° F. are not ordinarily considered as being especially destructive of peroxidase, the time and temperature relationships involved in heating the contents of the tank to 160° F. as well as in the gradual cooling might well have had a marked effect on destroying peroxidase activity. Coupling the above heat-treatment with the accompanying changes of water necessary to leach the salt from the pickles, it is not surprising to find the peroxidase content reduced to a level undetectable under the test conditions.

Despite the fact that residual peroxidase was not detectable in the freshened salt stock pickles, the possibility was considered that this enzyme might regenerate in pickle products prepared from these pickles. This phenomenon was reported by Schwimmer *(11)* who noted that the peroxidase enzymes of turnip and cabbage regained their activity after apparent heat inactivation and also by Guyer and Holmquist *(2)*, who noted it in canned peas. However, Kaplan *et al. (5)* found no such reactivation of peroxidase in salt stock pickles provided the thermal processing was sufficient to destroy enzyme activity totally.

Consequently, 24 jars of each of the 5 pickle products prepared from each of the two original salting tanks were set aside at the time of packing. The pH, total acid (as acetic), and soluble solids values of these packs are presented in Table 3. Peroxidase tests were run on each

TABLE 3

Total acid, pH, and soluble solids in various pickle packs

Product	pH	Acid (as acetic) %	Soluble solids %
Processed dill pickles	3.08	0.89	7.8
Processed dill chips	3.08	1.01	7.8
Sour pickles	2.99	1.86	7.3
Sweet mixed pickles	2.80	2.15	39.7
Processed Kosher dill pickles	3.08	0.85	7.2

the pickle packs immediately after packing as well as at the end of 1, 2, 3, 4, 8 and 32 weeks of storage at room temperature.

According to the tests, peroxidase activity in the pickle products was non-existent. These results indicate that peroxidase regeneration either did not occur or was too weak to be measurable under test conditions. These findings are not entirely incompatible with those of Schwimmer *(11)*, inasmuch as he utilized the original peroxidase content of cabbage and turnip. However, in the present study, the salt stock pickle product tested for regeneration had been depleted of a very large proportion of its original peroxidase activity.

It would thus appear that if peroxidase were a factor in causing off-flavors in salt stock pickles, it would have to take effect in the salting and curing tanks rather than in the finished pickle products.

SUMMARY

An investigation of the activity and stability of peroxidase in salt stock pickles under commercial conditions indicated a relatively rapid and continuous decrease in peroxidase within the pickle during the first 20 weeks of fermentation and storage. In the remaining 23 additional weeks of storage no further reduction was apparent.

Peroxidase concentrations in the covering salt brines were not detectable at first, but equilibrated with those in the pickles within seven days. They then remained equal to or greater than the concentrations in the pickles for the remainder of the storage period.

After commercial freshening operations, the peroxidase concentration within the freshened salt stock pickles was reduced to a level that was nondetectable under the test conditions.

After manufacturing the freshened salt stock into five commercial pickle products, initial examinations of each pickle product revealed no peroxidase activity nor was any regeneration of this enzyme apparent in any of the pickle packs during a seven-month storage period at room temperature.

LITERATURE CITED

1. Anderson, E. E., Ruder, L. F., Esselen, W. B., Jr., Nebesky, E. A., and Labbee, M. Pasteurized fresh whole pickles. II. Thermal resistance of microorganisms and peroxidase. *Food Technol.*, **5**, 364 (1951).
2. Guyer, R. B., and Holmquist, J. W. Enzyme regeneration in high temperature—short time sterilized canned foods. *Food Technol.*, **8**, 547 (1954).
3. Joslyn, M. A., and Bedford, C. L. Enzyme activity in frozen vegetables. *Ind. Eng. Chem.*, **32**, 702 (1940).
4. Joslyn, M. A., and Marsh, G. L. Role of peroxidase in the deterioration of frozen fruits and vegetables. *Science*, **78**, 174 (1933).
5. Kaplan, A. M., Esselen, W. B., Jr., and Fellers, C. R. Enzyme systems of canned acid foods. *Ind. Eng. Chem.*, **41**, 2017 (1949).
6. Labbee, M. D. The relationship of peroxidase and catalase activity to the development of off-flavor and color in processed pickles. (Ph.D. thesis, University of Massachusetts, 1952).
7. Labbee, M. D., and Esselen, W. B. Effect of peroxidase concentration, acidity, and storage temperature on the development of off-flavors in fresh pack pickles. *Food Technol.*, **8**, 50 (1954).
8. Nebesky, E. A., Esselen, W. B., Jr., and Fellers, C. R. Studies on the peroxidase in pickles and pears. *Food Technol.*, **5**, 110 (1951).
9. Nebesky, E. A., Esselen, W. B., Jr., Kaplan, A. J., and Fellers, C. R. Thermal destruction and stability of peroxidase in acid foods. *Food Research*, **15**, 114 (1950).
10. Reddi, R. R., Esselen, W. B., Jr., and Fellers, C. R. Peroxidase activity of apple tissue. *Food Technol.*, **4**, 63 (1950).
11. Schwimmer, S. Regeneration of heat-inactivated peroxidase. *J. Biol. Chem.*, **154**, 487 (1944).
12. Tressler, D. K., and Evers, C. E. *The Freezing Preservation of Foods.* 1947, 2nd ed., Avi Publishing Co., New York.

A Household and a Laboratory Type of Panel for Testing Consumer Preference[a]

P. G. MILLER, J. H. NAIR, AND A. J. HARRIMAN
Thomas J. Lipton, Inc., Hoboken, N. J.

(Manuscript received March 2, 1955)

The ability of consumer panels to make preference evaluations of food products may be expected to vary with the degree of the differences between the products. Frequently these differences are small. For example, improvements in flavor or appearance of products already on the market are often deliberately made in small steps so that the resultant changes may be difficult for consumers to detect. Both consumer preference panels and the laboratory type of panel have been used by investigators in an attempt to get a measure of the probable relative acceptance of products having varying degrees of differences. Unlike public opinion polls, such as those taken just before an election, the accuracy of results of consumer preference tests is not easily determined. Many factors not evaluated in the preference test will affect reaction of the consumer to the product when placed on the market. Even when items of the type being tested are already in the channels of trade such factors as brand name, price, advertising, etc. may be expected to give results in sales movement contradictory to the expressed consumer response to the two products when submitted on a blind test.

The details of the consumer testing procedure used in obtaining results presented herein have been previously described by one of the authors.[b] Briefly, the consumer panel tests were conducted as follows:

The selection of a representative panel as well as the tabulation and analysis of results was done by market research agencies.

The client packed the samples being compared in plain containers, affixed code numbers and preparation directions, and inserted the two samples into a mailing container.

Along with the samples were mailed a letter of instructions, multiple questionnaires and a return addressed envelope requiring no postage.

The following is a typical letter of instructions:

Dear Consumer Juror:

This is a test of noodle soup which we would like to have you make. We want as many members of the family as possible to take part in the test, so try to serve the soups when you are all together.

Please serve soup No. 86 first, and in the next two or three days serve No. 74 to the same family members who tasted the first soup.

After you have completed the test, fill in the questionnaire marked Housewife and have the Family Member questionnaires filled in by those who took the test.

We would appreciate receiving your completed questionnaires as soon as possible, so try to start the test tomorrow. The return envelope requires no postage—as usual.

Thank you for helping us with this—and I hope you enjoy making the test.

Remember, taste No. 86 first.

Sincerely,

Note that one-half of the panel members were told to serve one sample first. An equal number was asked to serve the other sample first. In each case the second sample was to be prepared two or three days after serving the first one.

The data on this type of consumer panel which are reported in this paper reflect a total of over 20,000 individual choices. They are related to the precision of the test, and may or may not be an indication of the accuracy of this type of testing procedure. Although a degree of precision is necessary for accuracy, a high degree of precision does not necessarily imply a high degree of accuracy. This paper deals only with the responses to the question of the sample preferred. Analysis of the answers to the other questions leads to involvement in problems of interpretation, such as to whether the reasons reported for the choice arise from the natural tendency to justify the preference, or whether the sensations reported actually determined the choice. These considerations are beyond the scope of this paper.

The laboratory panel consisted of individuals who were not working with, or had a direct interest in, any of the foods being tasted; nor were they in the company submiting samples. In contrast to the procedure with the consumer panel, where the samples were served at meal time on different days, the laboratory-type of panel tested the sample not at meal time but in a side-by-side comparison between meal times. The consumer panels represent approximately 600 judgments per comparison, while the laboratory panel involved 50 to 75 persons.

Market research specialists readily admit that the "mail-away" consumer preference testing method as discussed in this paper does not have the degree of perfection desired, but, approximate as the procedure may be, it is generally considered that the information obtained is well worth the moderate cost of such tests. More expensive consumer testing procedures may or may not be justified on the basis of information obtained.

[a] Paper presented at the Fourteenth Annual Meeting of the Institute of Food Technology, Los Angeles, California.

[b] See "Mass Panel Testing," J. H. Nair, FOOD TECHNOLOGY, 3, 131-136 (1949).

RESULTS AND DISCUSSION

It is usually observed that the degree of preference between a pair of samples varies with the order in which the samples are tested. The presentation used by the market research agency to show the effect of order of tasting is illustrated by the data in Table 1. From data like these the size of panel was adjusted for *no report* and for the unequal numbers tasting the pair of samples in different order as illustrated by the data in Table 2.

The *like both equally* and *don't like either* responses were divided equally between preferences for No. 86 and No. 74 for the portion of the panel tasting No. 86 first and for the portion tasting No. 74 first. These percentages were then corrected for the *no report* groups and rounded off to the nearest 0.5%. To compensate for occasional large differences in numbers between the two halves of the panel responding, the average of the corrected percentages tasting the samples in different order was taken as the whole or total panel preference.

The total preference and preference with order of testing are presented in Figure 1. The preference ratio of the whole panel is plotted along the abscissa. The ratio of the preference of the half of the panel tasting first the sample preferred by the whole panel to the preference for this same sample of the half tasting it second is plotted along the ordinate. This is an attempt to evaluate the effect of the order of tasting as a bias. By this procedure a value of one indicates its absence, whereas a ratio greater than one indicates a bias for the sample tasted first. A value of less than one is in like manner some evidence of a bias for the sample tasted second.

TABLE 1

Preferences of the whole panel and of the two fractions tasting the paired samples in different order

	Total	Tasted No. 86 First	Tasted No. 74 First
All testers	736[1]	372	356
	%	%	%
Prefer No. 86	37	36	39
Prefer No. 74	29	32	26
Like both equally	27	26	28
Don't like either	6	6	6
No report	1	—	1
	100	100	100

[1] Includes 8 people who did not report on which sample they tasted first.

The upper section of Figure 1 portrays the results when the products being compared differed only slightly in flavor and appearance. Three out of the 11 comparisons show no bias due to the order of tasting. In 6 comparisons the indicated bias was in favor of the sample tasted first, whereas two show the bias in favor of the sample tasted second.

The overall panel results were in line with that arrived at by the company laboratory staff, except for one comparison with a preference of more than 1.3 to 1 and no evident bias due to order of tasting. In two other tests with a preference ratio of 1.17 to 1, which would be considered significant from a statistical standpoint, the bias for the order of tasting was in opposite directions. Taken as a whole, these results are not too surprising when it is considered that the samples being compared were very similar. It might be expected that the panel felt the necessity of stating a preference, and, in so doing, other factors involved in the tasting of the product might well exert considerable influence in selecting one sample over the other.

TABLE 2

Preferences adjusted for no preference and to give equal number tasting the paired samples in different order.

	Total	Tasted No. 86 First	Tasted No. 86 Second
	%	%	%
Prefer No. 86	54	52	56.5
Prefer No. 74	46	48	43.5
	100	100	100
Adjusted panel size	704	352	352

$$\text{Total preference ratio} = \frac{54}{46} = 1.17.$$

$$\text{Preference when tasted } \frac{\text{first}}{\text{second}} = \frac{52}{56.5} = 0.92.$$

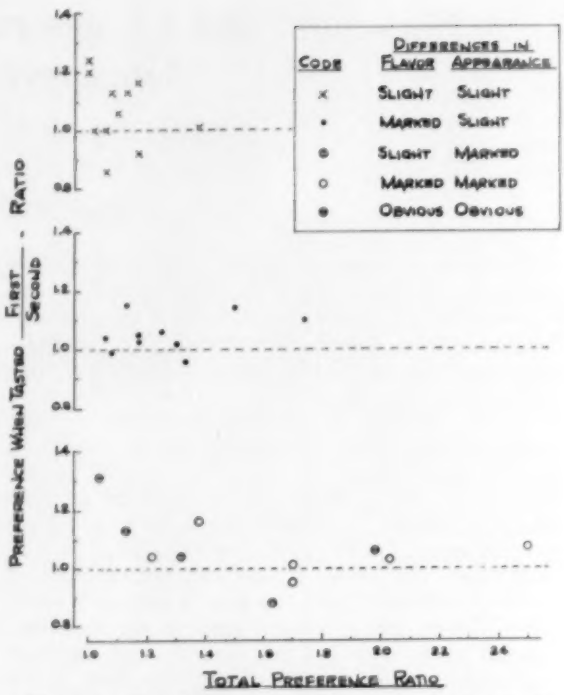


Figure 1. The whole panel preference compared with the preference of the two halves of the panel tasting the overall preferred sample in opposite order when the differences between the two samples varied from slight to obvious.

The middle section of Figure 1 presents results obtained with comparisons of samples formulated to have a marked difference in flavor but only a slight difference in appearance. The pattern of these results is a little different from that obtained with samples differing only slightly in both flavor and appearance, as shown in the upper section of the figure. The bias for the order of tasting appears to be more uniformly in favor of the sample tasted first. Also, in 8 out of 10 comparisons the panel results indicate a significant preference for one sample over the other. One might predict that some of the comparisons would not result in a significant preference vote. What the laboratory personnel considered a marked difference might or might not be so judged by the average consumer. Also, even if a difference did exist, it does not necessarily follow that there should be a preference for one over the other.

In the lower section of Figure 1 are presented results reported when the samples being compared had differences that should have been visually perceptible to the consumer panel members. In one comparison the difference in flavor was very slight whereas the difference in appearance was marked. In this comparison a slight bias was shown for order of tasting, and definite preference was shown for one sample over the other. In 6 comparisons the differences in appearance and flavor were both marked. The preferences expressed varied from slight to an extremely high preference for one sample over the other. Again the bias was in favor of the sample tasted first, except in one case in which the bias was for the sample tasted second. In the third set of comparisons the differences in flavor and appearance were great enough to be quite obvious to all tasting the products. Yet the results for these 4 comparisons appear to be

erratic both as to degree of preference, and bias due to the order of tasting.

In running these consumer tests, the panel members were given the opportunity to express a *no preference* vote. In Figure 2 is presented the percentage of *no preference* votes given by the consumer panels when comparing samples differing from *only slightly* to *obvious* in flavor and appearance.

The upper section of Figure 2 gives the results when comparing samples differing only slightly in flavor and appearance. As would be expected, in such comparisons the percentage of *no preference* votes was generally high.

In the middle section of Figure 2, the samples being compared had a marked difference in flavor, but only a slight difference in appearance. Here appear two groups of points, one with a high degree of *no preference*, the other with a relatively low degree of *no preference* votes. The groupings do not appear to be related to the degree of preference for one sample over another. The group of comparisons in which the *no preference* vote ran high shows a slight tendency for the *no preference* vote to decrease as the preference for one sample over another increased.

The lower section of Figure 2 shows the *no preference* votes for comparisons in which the differences in appearance between the two samples were great enough to be evident to all consumers tasting the product. For the series of comparisons with a marked degree of difference in flavor and appearance between the samples, the percentage of *no preference* votes decreased as the preference for one sample over the other increased. For the set of comparisons in which the differences between the samples were quite obvious, no tendency was shown for a correlation between the *no preference* vote and the degree of preference.

Although there were exceptions, in general the *no preference* votes were high when comparing samples with only slight differences in flavor and appearance. A slightly lower degree of *no preference* was obtained when the differences in samples were marked in flavor only. On the other hand, when the differences between the sample were evident to the eye, the *no preference* votes were still lower. Three classifications of sample therefore seemed to be justified by these results. When considered in this manner the overall degree of correlation between the *no preference* vote and the preference is as great as might be expected under such conditions of preference testing.

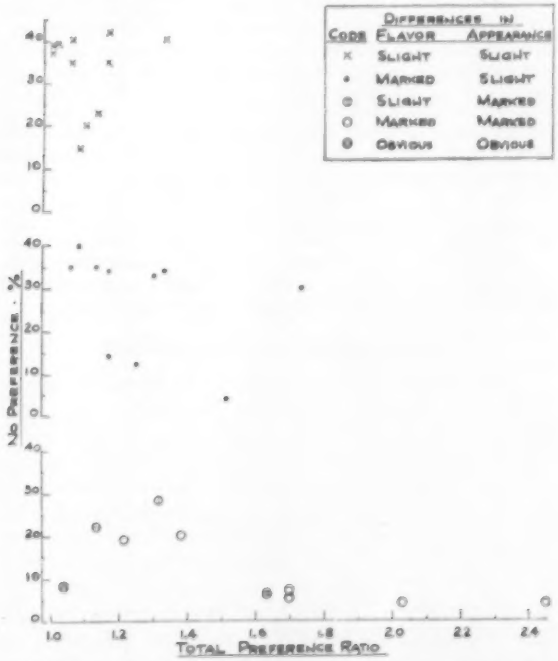


Figure 2. The total preference versus the no preference when the differences between the two samples being compared varied from slight to obvious.

Some data on attempts to check the consistency of consumer panels are presented in Table 3. Identical samples were submitted to consumer panels 1 and 2. The overall results of these two panels show very close agreement, and indicate no preference. However, as was mentioned in connection with the results obtained showing a comparison of samples quite similar in flavor and appearance, the preference varied considerably with the order of tasting and were reversed by the two panels. Since the samples were identical, the preference given by the two halves of the panel were not due to differences in the samples but to the influence of other factors in carrying out the test under these procedures. Apparently there are some significant uncontrolled factors influencing the judgment of consumers examining one sample one day and the other sample a day or more later.

In the other 3 series of checks shown in Table 3 the consumer panels were comparing samples differing in flavor and/or appearance. In the first set of these comparisons, involving samples B and C, the differences in flavor were marked whereas the differences in appearance were slight. Panel 3 preferred sample B over sample C by 57%, a ratio of 1.33 to 1. This falls at a very low chance level. For the half of the panel tasting B first the preference ratio was 1.25 to 1, while the preference ratio for the other half testing B second preferred B at the ratio of 1.38 to 1. Panel 4 did not confirm but completely reversed the preference vote of Panel No. 3, since it gave a preference ratio for C over B of 1.25 to 1, which also falls at a low chance level. The half-panel preference ratios for C were 1.35 to 1 for the half tasting C first and 1.15 to 1 for the half tasting C second. This is in reverse to the results obtained with Panel 3; that is, Panel 3 tended to show a preference for the sample tasted second, while Panel 4 tended to show a preference for the sample tasted first.

TABLE 3

Duplicate panel preferences when the differences between the paired samples varied from identical to marked

Panel		Sample getting the most total votes			
Duplicate	Size[1]	Sample	Total votes %	Votes when tasted	
				First %	Second %
Identical samples; A vs. A'					
1	614	A	51	54.5	47
2	564	A	51.5	47.5	55.5
Differences marked in flavor, slight in appearance; B vs. C					
3	496	B	57[2]	55.5	58[2]
4	692	C	55.5[2]	57.5[2]	53.5
Difference slight in flavor, marked in appearance; D vs. E					
5	574	D	57[2]	58.5[2]	56[2]
6	330	D	56.5[2]	55	58[2]
Difference marked in flavor, marked in appearance; F vs. G					
7	720	F	59[2]	60[2]	58[2]
8	334	F	59.5[2]	61[2]	58[2]

[1] Numbers adjusted to give equal weight to the two orders of tasting.
[2] Probability of getting this preference by chance is less than 1%.
[3] Probability of getting this preference by chance is less than 5%.

The significant conflict in preference shown by these two panels for the same set of samples raised the question as to how much of a preference must be obtained from a panel of this type in order to indicate accurately a significant preference for one over the other. The probability of obtaining such results by chance are extremely small and either of these panel results taken alone would normally be considered to show a high degree of preference for one sample over the other. A detailed study of answers to other questions in the questionnaire has not given any clue to an explanation of the reversal of these two panels.

In another set of comparisons where two panels compared samples D and E differing only slightly in flavor but markedly in appearance, the overall panel results show very good agreement. Panel 5 preferred sample D over E at a preference ratio of 1.33 to 1 while Panel 6 preferred sample D over E at a

RESULTS AND DISCUSSION

It is usually observed that the degree of preference between a pair of samples varies with the order in which the samples are tested. The presentation used by the market research agency to show the effect of order of tasting is illustrated by the data in Table 1. From data like these the size of panel was adjusted for *no report* and for the unequal numbers tasting the pair of samples in different order as illustrated by the data in Table 2.

The *like both equally* and *don't like either* responses were divided equally between preferences for No. 86 and No. 74 for the portion of the panel tasting No. 86 first and for the portion tasting No. 74 first. These percentages were then corrected for the *no report* groups and rounded off to the nearest 0.5%. To compensate for occasional large differences in numbers between the two halves of the panel responding, the average of the corrected percentages tasting the samples in different order was taken as the whole or total panel preference.

The total preference and preference with order of testing are presented in Figure 1. The preference ratio of the whole panel is plotted along the abscissa. The ratio of the preference of the half of the panel tasting first the sample preferred by the whole panel to the preference for this same sample of the half tasting it scond is plotted along the ordinate. This is an attempt to evaluate the effect of the order of tasting as a bias. By this procedure a value of one indicates its absence, whereas a ratio greater than one indicates a bias for the sample tasted first. A value of less than one is in like manner some evidence of a bias for the sample tasted second.

TABLE 1
Preferences of the whole panel and of the two fractions tasting the paired samples in different order

	Total	Tasted No. 86 First	Tasted No. 74 First
All testers	736[1]	372	356
	%	%	%
Prefer No. 86	37	36	39
Prefer No. 74	29	32	26
Like both equally	27	26	28
Don't like either	6	6	6
No report	1	....	1
	100	100	100

[1] Includes 8 people who did not report on which sample they tasted first.

The upper section of Figure 1 portrays the results when the products being compared differed only slightly in flavor and appearance. Three out of the 11 comparisons show no bias due to the order of tasting. In 6 comparisons the indicated bias was in favor of the sample tasted first, whereas two show the bias in favor of the sample tasted second.

The overall panel results were in line with that arrived at by the company laboratory staff, except for one comparison with a preference of more than 1.3 to 1 and no evident bias due to order of tasting. In two other tests with a preference ratio of 1.17 to 1, which would be considered significant from a statistical standpoint, the bias for the order of tasting was in opposite directions. Taken as a whole, these results are not too surprising when it is considered that the samples being compared were very similar. It might be expected that the panel felt the necessity of stating a preference, and, in so doing, other factors involved in the tasting of the product might well exert considerable influence in selecting one sample over the other.

TABLE 2
Preferences adjusted for no preference and to give equal number tasting the paired samples in different order.

	Total	Tasted No. 86 First	Tasted No. 86 Second
	%	%	%
Prefer No. 86	54	52	56.5
Prefer No. 74	46	48	43.5
	100	100	100
Adjusted panel size	704	352	352

$$\text{Total preference ratio} = \frac{54}{46} = 1.17.$$

$$\text{Preference when tasted} \frac{\text{first}}{\text{second}} = \frac{52}{56.5} = 0.92.$$

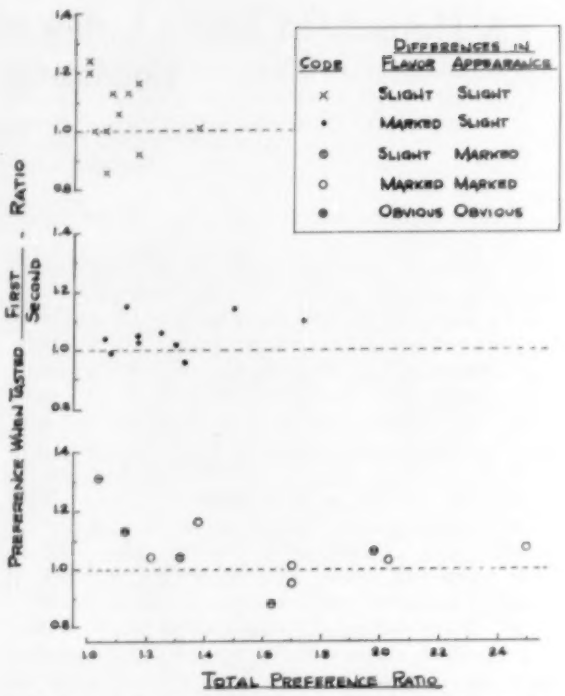


Figure 1. The whole panel preference compared with the preference of the two halves of the panel tasting the overall preferred sample in opposite order when the differences between the two samples varied from slight to obvious.

The middle section of Figure 1 presents results obtained with comparisons of samples formulated to have a marked difference in flavor but only a slight difference in appearance. The pattern of these results is a little different from that obtained with samples differing only slightly in both flavor and appearance, as shown in the upper section of the figure. The bias for the order of tasting appears to be more uniformly in favor of the sample tasted first. Also, in 8 out of 10 comparisons the panel results indicate a significant preference for one sample over the other. One might predict that some of the comparisons would not result in a significant preference vote. What the laboratory personnel considered a marked difference might or might not be so judged by the average consumer. Also, even if a difference did exist, it does not necessarily follow that there should be a preference for one over the other.

In the lower section of Figure 1 are presented results reported when the samples being compared had differences that should have been visually perceptible to the consumer panel members. In one comparison the difference in flavor was very slight whereas the difference in appearance was marked. In this comparison a slight bias was shown for order of tasting, and definite preference was shown for one sample over the other. In 6 comparisons the differences in appearance and flavor were both marked. The preferences expressed varied from slight to an extremely high preference for one sample over the other. Again the bias was in favor of the sample tasted first, except in one case in which the bias was for the sample tasted second. In the third set of comparisons the differences in flavor and appearance were great enough to be quite obvious to all tasting the products. Yet the results for these 4 comparisons appear to be

erratic both as to degree of preference, and bias due to the order of tasting.

In running these consumer tests, the panel members were given the opportunity to express a *no preference* vote. In Figure *2* is presented the percentage of *no preference* votes given by the consumer panels when comparing samples differing from *only slightly* to *obvious* in flavor and appearance.

The upper section of Figure *2* gives the results when comparing samples differing only slightly in flavor and appearance. As would be expected, in such comparisons the percentage of *no preference* votes was generally high.

In the middle section of Figure *2*, the samples being compared had a marked difference in flavor, but only a slight difference in appearance. Here appear two groups of points, one with a high degree of *no preference*, the other with a relatively low degree of *no preference* votes. The groupings do not appear to be related to the degree of preference for one sample over another. The group of comparisons in which the *no preference* vote ran high shows a slight tendency for the *no preference* vote to decrease as the preference for one sample over another increased.

The lower section of Figure *2* shows the *no preference* votes for comparisons in which the differences in appearance between the two samples were great enough to be evident to all consumers tasting the product. For the series of comparisons with a marked degree of difference in flavor and appearance between the samples, the percentage of *no preference* votes decreased as the preference for one sample over the other increased. For the set of comparisons in which the differences between the samples were quite obvious, no tendency was shown for a correlation between the *no preference* vote and the degree of preference.

Although there were exceptions, in general the *no preference* votes were high when comparing samples with only slight differences in flavor and appearance. A slightly lower degree of *no preference* was obtained when the differences in samples were marked in flavor only. On the other hand, when the differences between the sample were evident to the eye, the *no preference* votes were still lower. Three classifications of sample therefore seemed to be justified by these results. When considered in this manner the overall degree of correlation between the *no preference* vote and the preference is as great as might be expected under such conditions of preference testing.

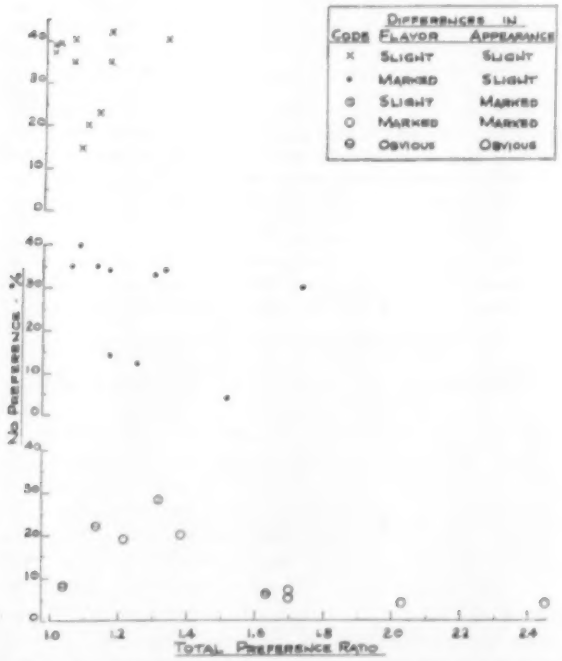


Figure 2. The total preference versus the no preference when the differences between the two samples being compared varied from slight to obvious.

Some data on attempts to check the consistency of consumer panels are presented in Table 3. Identical samples were submitted to consumer panels 1 and 2. The overall results of these two panels show very close agreement, and indicate no preference. However, as was mentioned in connection with the results obtained showing a comparison of samples quite similar in flavor and appearance, the preference varied considerably with the order of tasting and were reversed by the two panels. Since the samples were identical, the preference given by the two halves of the panel were not due to differences in the samples but to the influence of other factors in carrying out the test under these procedures. Apparently there are some significant uncontrolled factors influencing the judgment of consumers examining one sample one day and the other sample a day or more later.

In the other 3 series of checks shown in Table 3 the consumer panels were comparing samples differing in flavor and/or appearance. In the first set of these comparisons, involving samples B and C, the differences in flavor were marked whereas the differences in appearance were slight. Panel 3 preferred sample B over sample C by 57%, a ratio of 1.33 to 1. This falls at a very low chance level. For the half of the panel tasting B first the preference ratio was 1.25 to 1, while the preference ratio for the other half testing B second preferred B at the ratio of 1.38 to 1. Panel 4 did not confirm but completely reversed the preference vote of Panel No. 3, since it gave a preference ratio for C over B of 1.25 to 1, which also falls at a low chance level. The half-panel preference ratios for C were 1.35 to 1 for the half tasting C first and 1.15 to 1 for the half tasting C second. This is in reverse to the results obtained with Panel 3; that is, Panel 3 tended to show a preference for the sample tasted second, while Panel 4 tended to show a preference for the sample tasted first.

TABLE 3

Duplicate panel preferences when the differences between the paired samples varied from identical to marked

Panel		Sample getting the most total votes			
Duplicate	Size[1]	Sample	Total votes %	Votes when tasted	
				First %	Second %
Identical samples; A vs. A'					
1	614	A	51	54.5	47
2	564	A	51.5	47.5	55.5
Differences marked in flavor, slight in appearance; B vs. C					
3	496	B	57[2]	55.5	58[2]
4	692	C	55.5[2]	57.5[2]	53.5
Difference slight in flavor, marked in appearance; D vs. E					
5	574	D	57[2]	58.5[2]	56[2]
6	330	D	56.5[2]	55	58[2]
Difference marked in flavor, marked in appearance; F vs. G					
7	720	F	59[2]	60[2]	58[2]
8	334	F	59.5[2]	61[2]	58[2]

[1] Numbers adjusted to give equal weight to the two orders of tasting.
[2] Probability of getting this preference by chance is less than 1%.
[3] Probability of getting this preference by chance is less than 5%.

The significant conflict in preference shown by these two panels for the same set of samples raised the question as to how much of a preference must be obtained from a panel of this type in order to indicate accurately a significant preference for one over the other. The probability of obtaining such results by chance are extremely small and either of these panel results taken alone would normally be considered to show a high degree of preference for one sample over the other. A detailed study of answers to other questions in the questionnaire has not given any clue to an explanation of the reversal of these two panels.

In another set of comparisons where two panels compared samples D and E differing only slightly in flavor but markedly in appearance, the overall panel results show very good agreement. Panel 5 preferred sample D over E at a preference ratio of 1.33 to 1 while Panel 6 preferred sample D over E at a

TABLE 4

Panel preferences with repeated tests on a pair of samples differing markedly in flavor and slightly in appearance

Trial	Sample getting the most total votes			
	Sample	Total votes	Votes when tasted	
			First	Second
		%	%	%
First	L	60[1]	64[1]	56
Second	M	51	47.5	55
Third	L	52.5	54	51

[1] Pobability of getting this preference by chance is less than 1% (panel size 332).

preference ratio of 1.30 to 1. Panel 5 showed the usual trend of favoring the sample tasted first, while Panel 6 favored the sample tested second.

The final set of comparisons presented in Table 3, samples F versus G, differed markedly in both flavor and appearance. The two panels, 7 and 8, show very good agreement in preferring F over G, the preference ratio for F over G being 1.44 to 1 in one case and 1.47 to 1 in the other. Both of these results fall at a very low chance level. Also, both panels tended to favor the sample tasted first.

Results of another check on the consistency of consumer panels of the type under consideration are presented in Table 4. In this series a pair of samples with a marked difference in flavor and only a slight difference in appearance was submitted to a panel on 3 successive tests, using only the data from those taking part in all 3 tests. Upon first trial the panel preferred sample L over M at a preference ratio of 1.5 to 1. The probability of getting such a preference by pure chance is extremely small. The panel results indicate a tendency to prefer the sample tasted first. Upon the second test, the panel did not confirm its previous verdict. It essentially showed no preference for either sample. Slightly more votes were given for M than L, with a preference ratio of 1.04 to 1. Upon the third trial with this set of samples, the panel tended to return to its first verdict of preferring L over M with a small preference ratio of 1.11 to 1.

Considering these results alone, it would appear that the reaction of the consumer to the samples changed with repeated tasting. For example, it might be considered that the flavor appearing in the one sample in contrast to the other was not significant in influencing preferences upon further testing. However, in view of the results presented in the previous table on a similar set of samples differing markedly in flavor but not in appearance, it seems doubtful whether or not a preference ratio of 1.5 to 1 is great enough to be significant even though the chance level is low. In the previous case (Table 3, B vs. C) one panel completely reversed the verdict of another panel.

In Figure 3 is another check of an entirely different type upon the results obtained with consumer panels. In this case, the preference ratio of a consumer panel is compared with the preference ratio obtained by use of a laboratory type panel. The different symbols represent the same degree of difference in flavor and appearance as was given on the previous figures. There was a certain degree of agreement between the two panels. By usual statistical methods the sample significantly preferred by the laboratory panel was also preferred by the consumer panel. The reverse of this does not apply. The usual statistical methods of comparing the two panels get involved in size of panels, and other factors. For example the conditions under which the consumer panel compared the two samples contain a number of uncontrolled factors, whereas the laboratory panel compared the two samples under very carefully controlled conditions. This is indicated by a tendency for the laboratory panel to show a greater degree of preference than was obtained by the consumer panel. A comparison of preference ratios as given here seems to be fairer than comparisons from a statistical basis. Results are not available to show what the preference of the laboratory panel might be were the size of panel greatly increased so as to approach the numbers used in the consumer panels.

Considering individual comparisons the samples differing only slightly in flavor and appearance did not get a preference

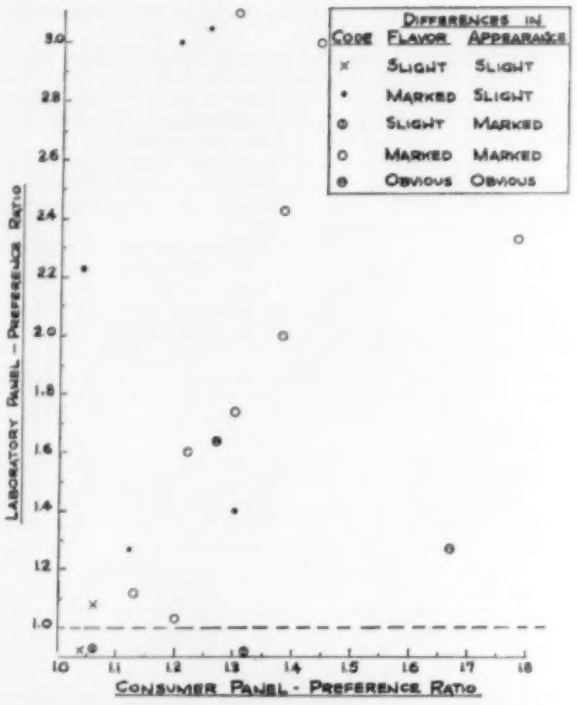


Figure 3. Consumer panel preferences compared with the preferences of a laboratory-type of panel.

by either panel. With samples that did not differ in appearance but had a marked difference in flavor the preferences were for the same samples by the consumer panel and the laboratory panel except for one set of comparisons. In this case one sample seemed to be significantly preferred by the consumer panel whereas the laboratory panel indicated a slight preference for the other sample. For the two comparisons in which the samples differed essentially only in their appearance, the laboratory panel in both cases gave results opposite to the preference obtained with the consumer panel. For the 9 sets of comparisons in which the differences in flavor and appearance were marked, the laboratory panel had no signficant preference in two of the tests. For the other comparisons in this set both panels tended to prefer to a significant extent the same sample. In the two comparisons in which differences in both flavor and appearance were quite obvious the consumer panel gave a strong preference for one of the samples, whereas the laboratory panel gave only a slight preference. Although there are discrepancies, these results show a degree of correlation between results obtained by these two entirely different types of preference tests.

OBSERVATIONS ON THE RESULTS

These results have been considered from the standpoint of a laboratory worker developing new food products or improving one currently in production. Ample checks and controls are desired for documenting facts to substantiate conclusions drawn. Although in many respects the results presented herein appear quite logical, some of the data raise serious doubts as to the validity of this particular testing method between food products which would be considered quite similar by many individuals. If panels of approximately 600 persons give preferences of high statistical reliability, as did many of those reported here, yet contradict one another on successive trials, one can scarcely hope to improve the precision of the verdict through an increase

in panel size to 2,000 judges, as suggested by some. On the other hand, panels of this larger size might give a verdict closer to the truth and thus improve the accuracy of the judgment.

SUMMARY

For a bland type of food product the consumer panels tended to show a bias for the sample tasted first. The bias due to order of tasting tended to be more erratic when comparing samples differing only slightly in flavor and appearance.

The *no preference* votes were high in comparison of products similar in flavor and appearance, and tended to decrease as the difference in flavor and/or appearance became greater. The *no preference* votes tended to decrease as the preference for one sample over the other increased.

Two panels testing identical (i.e. duplicate) samples gave no preference for either sample but the bias due to the order of tasting was large. Two panels comparing the same samples differing essentially only in flavor gave large preferences for one over the other, but opposite samples were chosen by the two panels.

Comparisons of samples with marked differences in appearance gave good checks with duplicate panels. A panel judging a pair of samples differing essentially only in flavor gave a large preference for one over the other on the first test, but upon succeeding tests a definite preference was not indicated.

There was a general agreement in preference between the consumer panel and the laboratory type of panel.

The Particle Size of Semolina in Relation to Quality and Wheat Variety[a]

R. H. HARRIS, L. D. SIBBITT, AND G. M. SCOTT

North Dakota Agricultural Experiment Station, Fargo, North Dakota

(Manuscript received April 18, 1955)

The properties of five fractions of varying particle size, obtained from a sample of purified semolina were studied Ten wheat varieties are compared with regard to particle size distribution of purified semolina.

The particle size of commercially milled hard and soft wheat flours in relation to quality has been studied by Wichser and Shellenberger, and Wichser, Shellenberger and Pence *(8, 9)*. Particle size was found to be related to mixing and baking properties, and Harris *(3)* confirmed these results with experimentally milled hard red spring wheat flour. Harris and Scott *(4)* also showed that wheat varieties differ very significantly in their flour particle size distributions, and found that environment, as typified by growth location or year of growth, had a still greater effect upon the particle size distribution.

Irvine and Anderson *(7)* provided information on the differences in macaroni color of fractions separated from commercial and from experimentally milled semolina according to particle size, but did not investigate the effect of wheat variety on particle size distribution. Generally, the finer sized fractions had a smaller proportion of yellow and were duller, which was attributed partly to size alone, and partly to an increasing brownness.

A brief preliminary investigation, the results of which are shown in Table 1, indicated that semolina extraction and granulation had an important effect upon various semolina properties and the color of the resultant macaroni, as expected from *a priori* considerations. The semolinas were milled from a single sample of sound, good quality durum wheat and consisted of one unpurified sample, two purified samples of 60 and 50% extraction, and an aliquot of the 50% extraction semolina reground to flour fineness to pass a sieve approximately equivalent to a Tyler mesh No. 120 or exactly equal to 110 which apparently is not manufactured by the Tyler Co. It is evident that moisture, protein, ash content, and speckiness decreased directly with length of extraction. Moisture loss occurred through longer exposure of the material to room air when purifying and grinding to reduce granulation. Absorption tended to decrease also with extraction, but increased upon grinding the semolina to flour fineness. The greatest effect of length of extraction was on macaroni color, which increased from 2.0 brown for 70.9% extraction to 9.0 for 50% extraction. Reducing the yield from 70.9% to 60% through purification caused the score to change from 2.0 brown to 8.5, illustrating the remarkable improvement in color effected by experimental purification. Further purification raised the score from 8.5 to 9.0. Grinding the 50% extraction semolina to flour fineness resulted in raising the color score to 10.0.

It appeared to the investigators that a need existed for information on the characteristics of fractions from purified semolina, the material from which macaroni is processed in this laboratory, as well as on the effect of wheat variety upon particle size distribution in semolina. Accordingly the present report is concerned with the properties of five fractions of varying particle size which had been obtained from a sample of purified semolina, and compares the particle size distribution of purified semolina from 10 wheat varieties.

[a] Contribution from the Department of Cereal Technology. Published with the approval of the Director, North Dakota Agricultural Experiment Station, Fargo.

EXPERIMENTAL

Materials and methods. The semolinas were milled from durum wheats grown comparably in experimental plots at the Langdon, North Dakota, branch station. Table 2 provides information on the quality of these wheats. Nine were hybrids at various stages of production in the program for developing durums resistant to the 15 B stem rust complex. The tenth, Sentry, possesses some tolerance to 15 B, but is not as resistant as the others, as is evident from the test weight values. However, it has been released for growth in the durum-producing area as a stop-gap variety. The most promising hybrids are at the top with relatively high quality. Ash content is a minor factor but, other factors being equal, varieties which possess lower ash in their semolina are preferred. Under present conditions, these samples represent as normal a collection of durum varieties as can be obtained since they had not been materially damaged by rust. A composite was prepared from these semolinas by blending equal quantities from each in a MacLellan Batch Mixer for fractionating relatively large quantities by particle size for quality testing.

The method used for milling and purifying the samples has been described by Harris and Sibbitt *(5)*. Macaroni processing procedures have been reported by Binnington and Geddes and Harris, Sibbitt and Scott *(2, 6)*. Analytical methods have been described *(1)*. For particle size fractionation, metal Tyler sieves and numbers were used with a Ro-Tap shaker. The following procedure was used for all 5 sieves. One sieve was used at a time, placed above a metal pan which carried an under-sieve brush cleaner. Another small cloth cleaner was placed on the upper surface of the test sieve as described by Wichser, Shellenberger and Pence *(9)*. Starting with the sieve with smallest aperture size, 50 g. of semolina were distributed over the surface of the sieve and the sieve cover and pan attached. Optimum sieving time was determined for each mesh as described previously for flour particle size *(3)*. Figure 1 shows the weight of throughs plotted against time of sieving at one-minute intervals. Optimum sieving time is indicated for each sieve when the throughs tended to reach a constant value. There was little change beyond these values, indicating that attrition was a minor factor in increasing the amount of throughs.

For the larger quantities of semolina fractions required for analyzing and processing, a modified procedure was used. Fifty grams of the composite semolina were sieved on the finest sieve (60-mesh) for the minutes needed to approach a constant value of throughs for that particular mesh, then the overs were removed and a fresh sample of the composite semolina substituted. This procedure was repeated until a suitable weight of throughs was obtained. The next finer mesh was used for sieving the semolina retained on the first sieve, or overs, and so on until 32-mesh had been reached.

RESULTS AND DISCUSSION

Semolina fractions. Figure 2 represents the relative size distribution for the original and 5 semolina fractions at a magnification of 50X. Differences in the size of the particles comprising the fractions are very evident from the photomicrographs. The percentage distribution of the original semolina as shown below:

Tyler Sieve No.	*32*	*42*	*48*	*60*	*65*
Throughs, %	*99*	*71*	*50*	*22*	*6*

TABLE 2

Quality factors for the ten durums

(Arranged in order of decreasing test weight)

Wheat variety	Test weight	Wheat protein content [1]	Purified semolina yield	Semolina ash [1]	Macaroni visual color score [2]
	lbs./bu.	%	%	%	
LD 370	61.5	12.8	51.3	0.50	9.0
LD 372	61.5	12.4	54.6	0.53	10.0
LD 369	60.6	12.7	52.6	0.56	9.5
RL 3206	60.2	14.0	52.5	0.60	8.0
LD 364	60.1	13.9	53.0	0.53	7.0
CI 3255	58.9	14.1	51.1	0.62	6.0 Sl.P.
LD 368	58.8	14.3	52.3	0.58	7.5
RL 3207	58.6	13.8	51.8	0.60	8.5
Sentry	56.8	12.4	44.9	0.59	10.0
LD 357	53.1	12.1	42.4	0.57	9.5

[1] Expressed on 13.5% moisture basis.
[2] Sl.P = slightly pale.

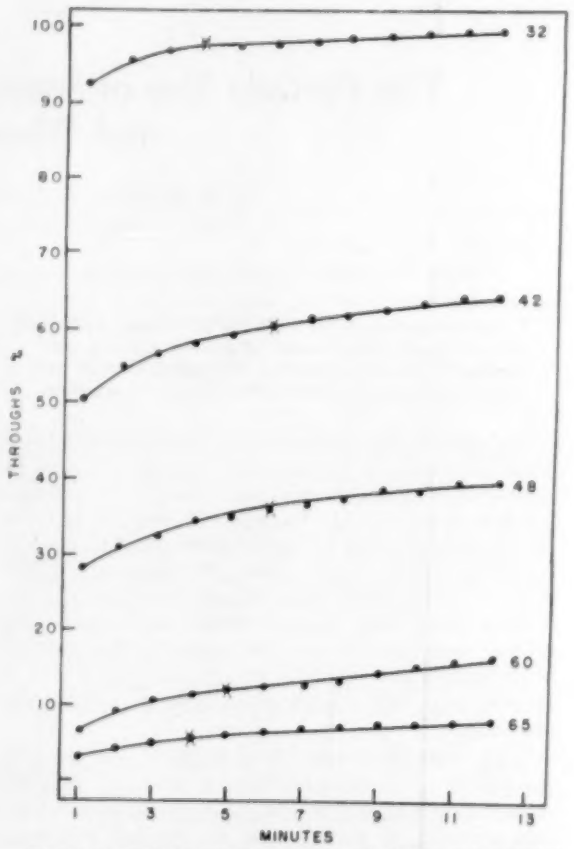


Figure 1. Relation between minutes of sieving and material passing each testing sieve. Optimum time indicated for each curve. Sieve numbers refer to number of meshes per linear inch (Tyler).

TABLE 1

Effect of extraction and granulation on semolina properties

Semolina description	Semolina moisture	Semolina protein [1]	Semolina yield		Ash [1]	Semolina specks per 10 sq. in.	Absorption	Macaroni visual color score [2]
			Unpurified	Purified				
	%	%	%	%	%		%	
Unpurified	14.1	12.7	70.9	Unpurified	0.67	75	28.4	2.0 Br.
Purified	13.5	12.5	71.2	60.0	0.53	33	27.5	8.5
Purified	13.0	12.3	70.5	50.0	0.47	10	26.7	9.0
Purified, 50% extraction, ground to flour fineness	12.4	12.1	70.8	50.0	0.44	20	33.0	10.0

[1] Expressed on 13.5% moisture basis.
[2] Br = brown.

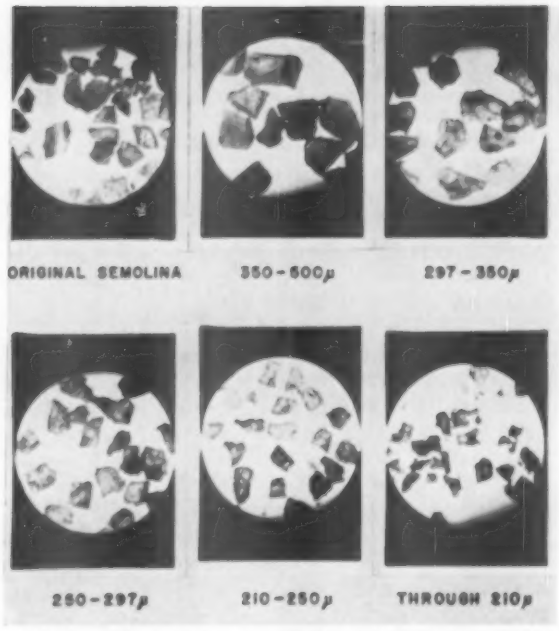


Figure 2. Photomicrographs of the particles for the original and five semolina fractions showing relative size distribution. Magnification: 50 ×.

Nearly all the material passed 32-mesh, while only 6% passed 65-mesh.

Table 3 shows the moisture, protein and ash contents of the original and 5 semolina fractions, with their absorptions and visual color scores. As noted for flour fractions similarly separated by Harris *(3)*, moisture loss increased with the number of sievings, with a total loss of 2.2% between the original semolina and the fractions passing 42- to 32-mesh. Harris found a corresponding loss of 2.3% between the original flour and the last fractions sieved. For both products, moisture loss increased with exposure to the laboratory atmosphere, which lacked humidity control.

For protein content there was no difference between the original semolina and the fractions, or among the fractions themselves. For flour, however, both Wichser *et al.* and Harris found that protein content increased as particle size decreased. Little difference in ash content was evident among the semolina samples except for the fraction passing 65-mesh, which contained significantly more ash. In flour fractionation, the portion passing the smallest mesh size also possessed the highest ash content. The fractions had higher absorption than the original semolina. Differences in absorption among the fractions themselves were not consistent.

As anticipated, particle size had a marked influence on the visual semolina color score. The color increased consistently with particle size, from 3.0 for material passing 65-mesh to 10.0 for the 32-mesh fraction, intimating that the durum miller can greatly influence and improve the color of his semolina product through judicious blending of various fractions consisting of different particle sizes.

Figure 3 represents the visual color score assigned the macaroni processed from the original and 5 semolina fractions. The fraction passing the largest sieve apertures resembles the original semolina, while the score of the remaining 4 fractions tended to decrease directly with aperture size, coresponding roughly to

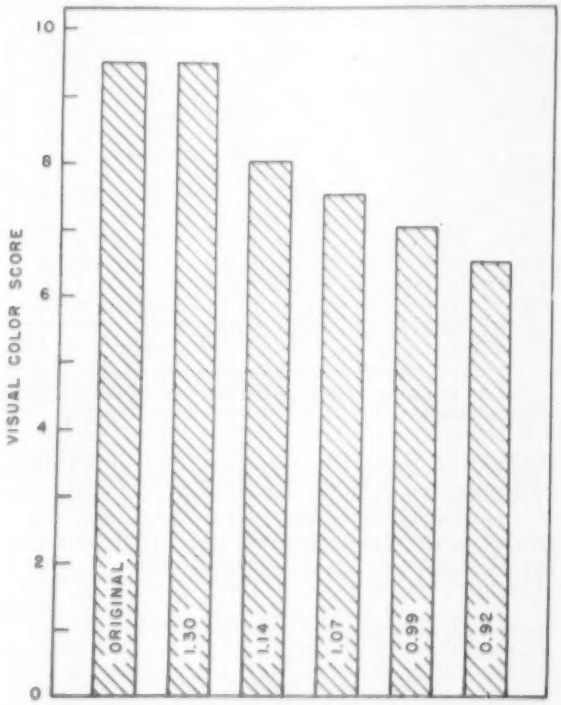


Figure 3. Color score of macaroni processed from the original and five semolina fractions passing indicated sieve apertures. Values shown are logarithms of diameter of sieve opening x 10^5.

semolina color score. These comparisons show that semolina granulation has a marked effect upon macaroni color. By suitable and carefully controlled classification of semolina granulation some degree of control of the color of the macaroni expected from a commercial mill's product is possible. However, it seems impossible for a mill to improve the color above that of the original unfractionated semolina through fractionation by particle size.

As the mixogram pattern did not appear to be significantly affected by particle size, in contrast to the pattern of flour fractions, which have been shown to vary

TABLE 3

Some properties of the original semolina and five fractions passing indicated meshes

Mesh No. (Tyler)	Diameter of Aperture x 10^5	Moisture	Protein content [1]	Ash [1]	Visual color score	Absorption
		%	%	%		%
Original Semolina		13.2	12.0	0.58	8.0	33.3
32	1.30	11.0	12.0	0.55	10.0	37.7
42	1.14	11.0	12.0	0.57	7.0	37.7
48	1.07	12.0	12.1	0.56	7.0	38.0
60	0.99	12.4	11.9	0.54	6.0	36.7
65	0.92	12.4	12.0	0.65	3.0	36.3

[1] Expressed on 13.5% moisture basis.

with particle size *(3, 8)*, it did not seem advisable to show the mixing curves in this report.

Particle size distribution. Figure 4 represents the upper and lower limits of the semolina particle size distribution for the 10 durum wheats, using the logarithm of the diameter of the sieve aperture x 10^3 [b] while Table 4 is an analysis of variance of the data. The effect of variety, while naturally not as large as that of sieve aperture size, was highly significant whether judged by the duplicate error or by the interaction of varieties x sieves. Thus, as for bread wheats, variety affects durum milling properties. This is a field that seems to have been neglected by research workers.

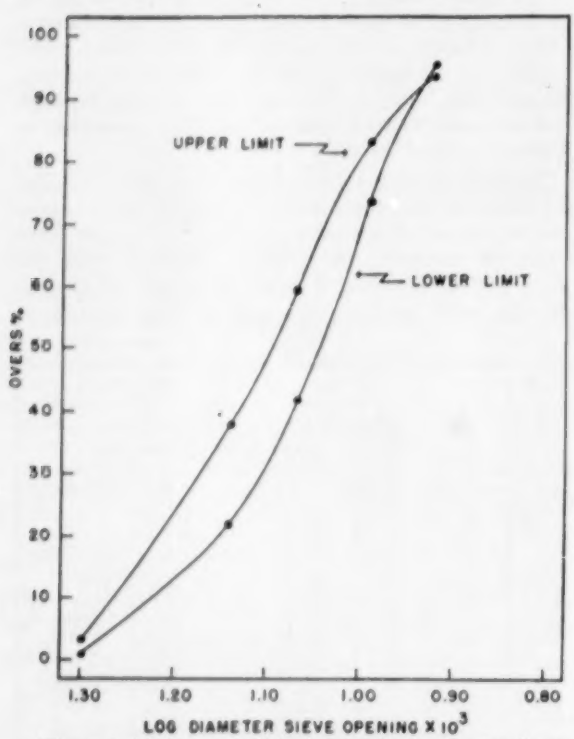


Figure 4. Limits of particle size distribution for ten durum wheat semolinas.

[b] "The profitable use of testing sieves," Catalog 53, p. 20-22, W. S. Tyler Co., Cleveland, Ohio. (1952).

TABLE 4

Analysis of variance of sieving data for ten durum wheats

Source of variation	Degrees of freedom	Variance	F (Duplicates as error)[1]	F (Varieties x sieves as error)[1]
Between Varieties	9	130.49	38.89	7.26
Between Sieves	4	27206.10	8109.12	1537.59
Interaction				
Varieties x Sieves	36	17.69	5.27	
Duplicates	50	3.36		

[1] All variances exceeded the 1% level of significance.

SUMMARY AND CONCLUSIONS

Length of extraction and granulation affected semolina properties, with protein and ash content and speckiness decreasing directly with length of extraction. Water absorption of the dough tended to decrease also. Macaroni color was greatly improved by decreasing the extraction, and to a lesser extent, by reducing the lowest extraction to flour fineness.

Samples separated from experimentally milled and purified semolina by particle size on a Ro-Tap shaker did not differ in protein or ash content except that the fraction with smallest particles contained the most ash. The fractions generally possessed higher absorption than the original semolina. Semolina and macaroni color, however, decreased markedly with particle size. Dough mixing properties were not significantly affected.

The semolina particle size distribution of ten durum wheats grown under comparable conditions at Langdon, North Dakota, differed very significantly, showing that variety affects particle size distribution for semolina in approximately the same manner as for flour.

LITERATURE CITED

1. American Association of Cereal Chemists. Cereal laboratory methods. 5th ed., 1947, The Association: St. Paul, Minn.
2. Binnington, D. S., and Geddes, W. F. Experimental durum milling and macaroni-making technique. *Cereal Chem.*, **13**, 497-521 (1936).
3. Harris, R. H. Flour particle size and its relation to wheat variety, location of growth, and some wheat quality values. *Cereal Chem.*, **32**, 38-47 (1955).
4. Harris, R. H., and Scott, G. M. Particle size distribution in experimentally milled flours from wheat varieties of various quality grown at six stations in North Dakota in 1953 and 1954. *Milling Prod.*, **20** (2) 1, 12-15 (February, 1955).
5. Harris, R. H., and Sibbitt, L. D. Experimental durum milling and processing equipment with further quality studies on North Dakota durum wheats. *Cereal Chem.*, **19**, 388-402 (1942).
6. Harris, R. H., Sibbitt, L. D., and Scott, G. M. Durum wheat testing methods for small samples. Part II. Processing methods. *Macaroni Journal*, **29**, (5) 10-12, 20 (1947).
7. Irvine, G. N., and Anderson, J. A. Factors affecting the color of macaroni. IV. Semolina particle size. *Cereal Chem.*, **29**, 65-70 (1952).
8. Wichser, F. W., and Shellenberger, J. A. Comparative studies in granulation of hard winter, hard spring and soft wheat flour. *Milling Prod.*, **13** (7) 1, 7, 27-29 (July, 1948).
9. Wichser, F. W., Shellenberger, J. A., and Pence, R. O. Relationship of physical properties of wheat flour to granulation. *Cereal Chem.*, **24**, 381-393 (1947).

Evaluating the Quality of Processed Foods

HOWARD R. SMITH

Washington Research Laboratory, National Canners Association, Washington, D. C.

(Manuscript received April 20, 1955)

The relative evaluation of food samples by one person is easy. But to assign to the evaluation numerical ratings that will stand up under challenge is not easy or simple. Within one organization the terms used to express quality may be any that are convenient. But communication with other processors requires a common language and a recognized scale of values. A method for establishing such a scale of values together with the difficulties and limitations that appear to be inherent in the task is the subject of this paper.

Satisfactory evaluation requires a set of product specifications. These start with a complete definition, such as a standard of identity under the Food, Drug and Cosmetic Act. Each quality factor must also be defined and, where necessary, each term used in the definition must in turn be defined.

After the best possible definition for each quality factor has been established, the technologist needs one more implement before he can evaluate a particular lot of processed food. That is a numerical system for expressing the degrees of that quality. Lord Kelvin expessed the need in an axiom: "If you can measure that of which you speak and can express it by a number, you know something of your subject, but if you cannot measure it your knowledge is meager and unsatisfactory." Certainly there are obvious advantages to numerical notations. The only objection appears to be that careless use of numbers can connote a degree of precision which may not be realistic. But, by limiting the numbers to be used, this tendency can be held to a reasonable minimum.

Most technologists feel that not more than ten steps between substandard and perfect quality can be detected with reasonable certainty by qualified observers. Some think only five gradations have any real significance. Notations in whole numbers from 1 to 10 are simple to use and are realistic with respect to the nature of most of the products and the types of qualities we have to evaluate. Much has been written on this subject *(1, 2, 3)*.

METHODS FOR MAKING THE EVALUATION

Objective tests. There is an understandable desire among all technologists for objective, completely impartial tests—especially those that yield numerical expressions of the quality factors. We would like to have for each quality of each food a scientific instrument as basic and easily operated as the refractometer. Of course, this particular instrument measures only the total soluble solids which is not a factor of quality. The type of instrument we desire is something to measure what the name "Succulometer" implies. That instrument measures the free liquid which can be expressed from foods under standard conditions. Although this is somewhat associated with desirable eating quality, it does not actually measure appetite appeal. If we could have an instrument which would measure *tenderness* for all types of teeth, *flavor* for all preferences, and *appearance* under all circumstances, we would be much farther along in our search for a satisfactory method for evaluating the quality of processed foods. But we do not have such instruments and the food technologist must make the best possible use of the limited facilities that are at his disposal *(4)*.

Organoleptic tests. In spite of the need for scientific objective tests to measure quality, most of the standards now in use depend largely on the personal opinion of the food examiner. Although this condition is unfortunate, it should not be unexpected. The values we are trying to measure have to do with the eating quality, which is a combination of the physiological and the psychological impression of the individual taster. Variations in the taste of individuals are always encountered in work of this kind and have come to be accepted as normal. Each technologist who has conducted tasting panels where conclusions are reported by secret ballot has been astonished at the wide variations reported on the same sample. Such differences are disconcerting but revealing. They serve to emphasize the variations in individual tastes with which we must work *(3)*.

Consider the plight of a single food technologist who is required to evaluate the quality of certain samples. He has accumulated all available information on this subject. He has at his disposal all of the objective test equipment. He has had experience in judging the quality of this product. How much success can he expect? How accurate can his notations of quality be?

In making the organoleptic examination, two factors enter in. First, the reliability the technologist has developed in evaluating that quality. Previous experience should have made clear to the technologist how closely he can duplicate his evaluations and, therefore, how reliable his individual ratings will be. Few, if any, food technologists seriously claim individual reliability greater than $\pm$ 1.0 in a ten-point scale.

The second consideration is the amount of experience the technologist has had in working with those qualified to explain the numerical notations. One man working alone can become expert in making comparative ratings, but only by checking his evaluations with recognized authorities in that field can he assign the standardized numerical values with confidence. Work with committees of technologists who are studying the formulation of standards is one of the best ways to become familiar with the significance of the numerical expressions now being established.

A splendid resumé of the information presently available on the entire subject of organoleptic methods for measuring qualities in food was published in 1951 by the U. S. Department of Agriculture. It contains a digest of all of the literature up to that time *(3)*.

What about the accuracy of the objective test? The results given by the test are as accurate as the test itself. That is, they are within the experimental error of the test. Each step in an analytical method has its limit of accuracy which contributes to the over-all error. And the sampling error is very real with many foods. The fruits and vegetables with which we work do not grow uniformly. There are always variations and gradations from one recognizable stage to the next. The work of the committee studying the test includes an investigation of all sources of error that may affect the accuracy of the test.

DEVELOPMENT OF OBJECTIVE TESTS

The application of the objective test results to the evaluation of the quality includes other considerations.

How is an objective test developed? Any method of testing that is consistent with the known facts and appears promising may be investigated. Samples of the

product representing all commercially important varieties, all important producing areas, all degrees of quality, and all methods of handling in processing are examined by the tests. Every effort must be made to have an adequate number of samples properly distributed over all of the variables. All of the samples are also evaluated for the quality factor being studied by at least two groups of examiners. The first evaluation is preferably made by a group of technologists from the industry concerned. Such men are familiar with the variations in the product and can be expected to give a careful individual rating. Each examiner makes his evaluation independently and submits a written rating according to the agreed notation system. We believe that the average of several opinions arrived at independently more nearly represents the average of a large population than does a "committee" judgment, where the single value is the result of consultation between the examiners. Too often in this latter case, one strong personality influences the decision.

The average of the numerical ratings for each sample is taken as the best rating for that sample and then compared by statistical methods with the results obtained by the objective test: If the degree of correlation between the two evaluations is satisfactory, the studies are continued. If not, the test is dropped unless some new development shows promise. Testing the reliability of any proposed test must extend over several seasons since possible product differences may exist from season to season due to growing conditions beyond the control of the processor. The second evaluation of the samples should be made by groups of processors of the product to make certain that the values being established are in line with merchandising experience. Since identicil values are never achieved by two groups of examiners, the final values must, of necessity, be a compromise of the values obtained.

From the statistical data, the regression line of the objective test values on the average evaluations is calculated and the best points of division of the objective values are determined. Statisticians would like to reverse this relationship, i.e., make the objective test the independent variable. But in this instance what we wish to measure is the *consumer acceptability* of the product, and the base value must be the average apparent value established by the organoleptic examination. The objective test under trial will be valuable only to the extent to which it yields figures that can be converted to acceptability.

The following illustration shows how the limits are determined:

We will assume that the values by the organoleptic ratings have been made on a scale of 1 to 9. The values by the proposed test on all of the samples range from 10 to 30. The trade uses three commercial grades for a product. The dividing points between the grades will be at 3.5 and 6.5 on the organoleptic ratings.

The statistical analysis of the data yields the correlation coefficient (r) and the equation of the regression line. By substituting the values 3.5 and 6.5 in this equation we obtain the objective test values indicated for these dividing points (Figure 1). In Figure 1, the dividing points are at 16.8 and 23.5. Samples yielding test values up to 16.8 would fall in one group; those from 16.9 to 23.5, in the second group; and those above 23.5, in the third group.

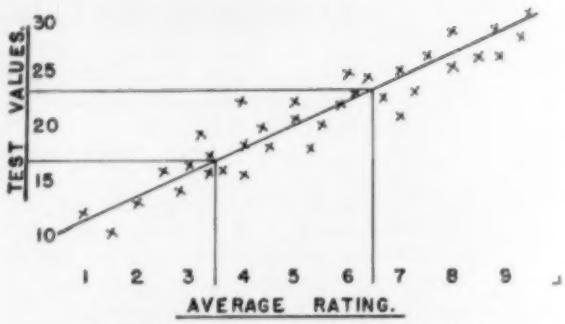


Figure 1. Relation of test results to ratings.

This is the method we use for finding the best single value of any test to show each dividing point. The regression line is the best line that will summarize the relationships. At the dividing point about half of the "border-line" samples will be above the limit and half below—just what we should expect and demand of an equitable standard.

The scattering of the points (Figure 1) is disturbing to some investigators. But different lots of the same kind of food do show marked variations. Organoleptic notations are inherently individual and not standardized. Each point on the figure is significant. It represents one proper sample, correctly tested by the proposed test, and carefully evaluated by each of several judges. It shows the actual relationship of the test result to the average organoleptic rating of that sample. No matter how abnormal part of the data may appear, unless actual typographical or mathematical error can be found, such data cannot be deleted or ignored.

The extent of the scattering of the points about the regression line is indicated mathematically by the correlation coefficient and the standard error of estimate. The correlation coefficient shows the degree of association between the two variables. It is widely used and quite generally understood. The values go from 0.0, indicating no correlation, to 1.0 indicating perfect correlation.

The standard error of estimate is less widely used outside of statistical circles. It measures the error to be anticipated in predicting test values from the average organoleptic rating. It indicates the width of the band on both sides of the regression line that will include about two-thirds of the points. In our example the value is $\pm$ 1.0. This is shown graphically on Figure 2 by the dotted lines (which have been added to Figure 1) indicating one standard error of estimate. A band that is 2 standard errors of estimate on each side would include about 95% of the points.

CORRELATION OF OBJECTIVE TEST AND ORGANOLEPTIC RATINGS

We cannot expect perfect correlation between any objective test and organoleptic ratings. A correlation

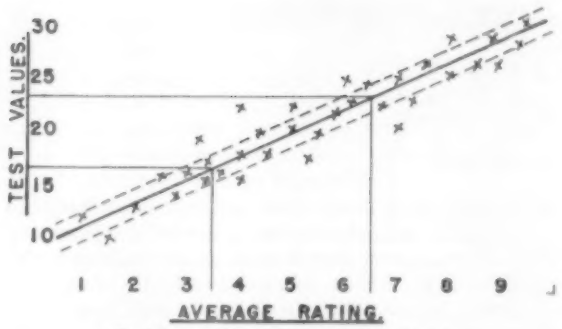


Figure 2. Standard error of estimate.

coefficient of 0.90 or better is good. We sometimes have to struggle with values down to 0.85 or even 0.80.

The dividing point finally selected must be infinitely sharp, i.e., so fine that no sample can rest on it. Every sample must fall to one side or the other. There cannot be any neutral zone between the classifications. But every processor will always have borderline lots, and they must be graded. The closest possible adherence to the test that an industry has established for itself is a sound policy for all branches of that industry.

Modern machinery has equalized the workmanship applied to products to the point where distinctions based on that factor are difficult to detect and, in many cases, of little significance. More and more, differences in quality are due to the nature of the raw product used. Differences in the processed products that are due to inherent differences in the commercial varieties used must be carefully considered. If it is not possible to distinguish these varieties in the final product with certainty, the variations in the processed product resulting from them must be accepted, of course, as a limiting factor in the precision of the classification.

Differences reported by separate groups of qualified examiners are sometimes so great as to be disturbing. If such differences are found to be persistent, thus indicating a definite difference of opinion with respect to relative quality, any single standard that is established can hardly satisfy everyone. We have had several experiences of this kind.

In setting the limits finally a certain amount of arbitrariness may be necessary. Differences of opinion must be weighed against the need for a standard and the absolute requirement that the standard must be a single definite point. Where only a minimum standard of quality is being set under the Food, Drug and Cosmetic Act, such a mandatory limit may well include a reasonable factor of safety to account for some of the variables. But any dividing point between other grades cannot be shifted without some inequality in one direction or another.

From the manner in which the dividing points on the objective test values are derived it is evident that they are always a compromise. They are the best single values that can be found and are accepted and used as such for guides in merchandising transactions. No one maintains that they are absolute or final. Developments within the industry may require a change in the dividing points. Few of the values fall exactly on the line (Cf. Figure 1). Those values that do not even come close to the line are just as real and valid, however, as any of the others.

In using an objective test in the classification of foods, we find that most lots fall easily into their proper groups. Those that are truly borderline may well be decided by the dividing point accepted for this purpose. Those few lots found to be unusual should receive special attention. They are not accidents or mistakes. They are merely different from the others. Such exceptions occur with every kind of food product and should be recognized as a normal variation inherent in all natural products. The existence of such lots does not invalidate the test. It does emphasize that the test is for voluntary use only—by those who understand its purpose and its limitations.

BY WAY OF SUMMARY

Both the organoleptic and the objective methods of testing foods have real limitations. The organoleptic method is easier, quicker, and, up to the point that the rating may be challenged, satisfactory. The objective method is impersonal and, if the limits are accepted by the whole industry, the classifications are impartial and equitable. But even the simplest objective test is not as fast as the organoleptic, and those that take considerable time are not practical for commercial use.

We do not know of any test, either organoleptic or objective, that can measure the quality of a lot of food exactly. Quality in food is a matter of opinion and, therefore, cannot be measured to the fraction of an inch or weighed on an analytical balance. At the sub-standard level certain definite values may be established in an arbitrary manner for enforcement purposes. But grades above sub-standard must reflect manufacturing and merchandising experience, and remain flexible enough to be practical.

Dr. Plank *(2)* concludes: "In the present state of development objective methods of determining and grading food quality may be regarded as very useful tools supplementing and controlling, but not replacing the subjective (organoleptic) tests. In estimating the comparative value of the two methods the subjective test based on immediate reactions of our senses must still be given the higher weight."

Many food technologists will agree with this conclusion.

LITERATURE CITED

1. Mackey, A. O., and Jones, P. Selecting members of a food tasting panel. *Food Technol.*, **8**, 527 (1954).
2. Plank, R. P. A rational method for grading food quality. *Food Technol.*, **2**, 241-51 (1948).
3. *Sensory Methods for Measuring Differences in Food Quality.* U. S. Department of Agriculture *Information Bull. 34* (1951).
4. Smith, H. R. Objective measurements of quality in food. *Food Technol.*, **1**, 345-350 (1947).

Packaging of Frozen Citrus Concentrates

D. W. RIESTER AND T. B. AYRES

Research and Technical Department, Technical Service Division, American Can Company, Tampa, Florida, and Los Angeles, California

(Manuscript received April 26, 1955)

In the origin of any completely new food product, much technical study is required. Because the production of frozen citrus concentrates has increased by leaps and bounds, problems have arisen that involve in their solution nearly all phases of food technology, including food chemistry, chemical engineering, mechanical engineering, bacteriology, and horticulture. Even the study of transportation facilities is involved.

The packaging of concentrates was one of the less obvious but very important problems which from the beginning called for extensive study. This paper covers the development and use of a container which protects frozen citrus concentrates from one of the deteriorating effects incident to distribution—adverse temperatures.

Concentrates were the first of the frozen foods to be marketed extensively in an hermetically sealed tin can. It is by far the most common container used today for frozen concentrated citrus juices. Occasional attempts have been made to use other types of packages, and new materials and methods may eventually make such packages economically feasible, but thus far the non-metallic or non-rigid container with satisfactory performance characteristics has proven to be too costly by comparison with the tin can. Either because of the materials in the container itself or because of the unavailability of high speed filling equipment, it has not proven to be economically competitive.

Early experience. The first commercial production of frozen citrus concentrates occurred in April, May, and June, 1946 and amounted to only 226,000 gallons. The following year it increased, but was still only 559,000 gallons—not high in contrast with today's production. Much of the initial production was marketed in 27 fluid ounce (401 x 411) size cans for restaurant or institutional use. Cans made of plain Common Coke tinplate were adopted because they were immediately available in the citrus industry. Since these cans had been successfully used for several years for sterile concentrates stored at 40° F. and even at room temperature, it seemed logical to assume that they would perform satisfactorily for a less concentrated product at 0° F. This line of reasoning was entirely sound so long as the storage and distribution temperatures remained within a few degrees of 0° F. The experience of the early years of relatively small scale production encouraged a complacent faith in the maintenance of ideal temperatures throughout distribution.

SOLVING PROBLEMS CAUSED BY ADVERSE TEMPERATURES

As the volume of production and the breadth of retail distribution increased, it became apparent that the concentrates were being subjected to abusive temperatures which promoted non-microbiological deterioration. The most apparent effect of such temperatures was the unsightly separation of suspended insoluble solids due to pectinesterase demethoxylation of the pectic substances. A slight degradation of flavor was also readily perceptible, but this effect was less objectionable than the appearance of the juice. Extensive efforts to educate carriers, distributors, retailers and consumers in the proper handling of frozen concentrates were initiated but they have been only partially effective. Progress along this line slowly continues, but a large portion of the product still encounters temperatures which must be considered abusive.

Internal corrosion. In 1948 there began to trickle back to the industry isolated reports of internal corrosion of the cans made of plain Common Coke tinplate. In all such instances samples were never available to show more than the effect of the product upon the container. As in instances of pulp separation, the common reaction to such complaints was to point out with some indignation that the product had not been stored properly. When it became evident that improper handling temperatures were not uncommon and would not be corrected quickly, steps were taken to meet existing conditions by adjusting both packaging methods and product preparation procedures.

The initial exploratory experiments to study can materials encompassed a large number of variables: (A) Two types of basic steel (Type L and Type MR) *(1)* were compared, the plate being drawn from three steel mills. (B) Three tin coatings, hot dipped Common Coke and No. 25 and No. 50 Electrolytic, *(2)* were applied to a single strip of steel. (C) Six internal organic coatings were evaluated. (D) Four potential methods of closure (standard, gas flow, steam flow and mechanical vacuum) were compared. (E) The need for an external varnish for the prevention of rust on the ends was studied. Orange concentrate was used in the first experimental packs because it was then the only concentrate packed in large volume.

In setting up laboratory test conditions it was decided that the container must protect the product for 6 weeks at 20° F. or 3 weeks at 40° F. Initially this was based upon fragmentary observations of commercial condition. Later, however, a market survey was conducted by a qualified outside agency and it was found that the test conditions represented the maximum common abuse to be expected and exceeded ordinary abuse by a considerable margin. Temperatures fluctuating between 0° and 20° F. on a 24-hour cycle had no effects not observed during continuous storage at 20° F. and 40° F. Periodic examinations were made daily at first but later reduced to once each week. No fewer than 6 samples of each variable were examined. Abusive storage tests

Presented before the Fourteenth Annual Meeting of the Institute of Food Technologists, Los Angeles, California, July 1, 1954.

were repeated after 3, 6, and 12 months in commercial warehouse subzero storage.

At the conclusion of the laboratory tests, four selected variables were represented by 34,000 cans in a semi-commercial test under market conditions. The number of variables was then reduced to two, and a commercial test of over 2 million cans was made.

The most outstanding observation made in these tests was the severe black product discoloration which occurs in the headspace area of plain cans under adverse storage conditions. In the plain Common Coke cans, which were then the commercial container, the headspace discoloration became objectionable in 7 days at 40° F. or in 24 days at 20° F., and it became progressively more severe over longer storage at these temperatures. Generally, the lighter the tin coatings, the more quickly the discoloration occurred and the more severe it became. Cans made of plain No. 50 and plain No. 25 tinplate showed objectionable headspace discoloration in 3 days and 2 days at 40° F., respectively, and in 20 days and 5 days at 20° F., respectively. Tin coating weight was the only tinplate factor tested which affected the degree of discoloration encountered; Type L basic steel and Type MR basic steel were equivalent in performance and represented the most corrosion resistant steel available for can manufacture.

Solving the problem of product discoloration. The solution of iron from the plain tinplate by the product caused the discoloration, presumably by reaction with some natural component of the concentrate. In sterile citrus products the atmospheric oxygen reacts quickly with the ascorbic acid and organic matter at elevated temperatures so that there is essentially no atmospheric oxygen available immediately after canning. Under such circumstances the tin-iron couple protects the steel from acid corrosion. On the other hand, frozen citrus concentrates are virtually saturated with atmospheric oxgyen at the time of filling and react with dissolved oxygen and headspace oxygen at a very slow rate at refrigerated storage temperatures. Until this oxygen is consumed, it is available to prevent the tin from protecting the steel at minute breaks in the tin coating, and ferric iron is dissolved freely.

The removal of more than half the headspace oxygen in a six ounce (202 x 314) can retards the discoloration to a considerable degree. If 95% of the oxygen is removed, the discoloration is almost entirely prevented under the abusive test conditions. Only the gas flow type of can closing machine, such as is commonly used in breweries, will attain this level of air removal on a practical basis; gas flow type machines displace the headspace air in the filled cans with carbon dioxide or nitrogen immediately prior to closure. Existing machinery for closing cans under high mechanical vacuum operates at speeds about one-quarter as fast as the other types of closing machines and is not practical. Closing machines which displace the headspace air with steam are in common commercial use; they can attain approximately 85% air removal from the headspace and produce a vacuum of 20 inches. Steam flow closure is not always used effectively, and at its best will not prevent entirely the objectionable headspace discoloration under adverse storage conditions.

Lining the can with an enamel completely prevented the headspace discoloration of the product throughout the test period. The application of organic coatings was effective on all of the tin coating weights. All six of the oleoresinous coatings were equivalent in this respect. Furthermore, special methods of closure did not improve the performance of the enamel lined cans.

If the black discoloration in the headspace is dispersed in the fluid concentrate by shaking the container, the discoloration becomes imperceptible by visual observation. Indeed, the pigment is apparently reduced, probably by ascorbic acid, to its original color. This phenomenon may well account for the fact that consumer complaints were largely confined to container corrosion rather than product discoloration during the early use of plain cans.

The discolored material itself had an off-odor and off-flavor which was readily detectable and which could only be described as "metallic." However, when the entire contents of the can were mixed with 3 volumes of water, as is customary, the off-odor and off-flavor were not perceptible.

Flavor effects. In considering the commercial conversion from plain Common Coke cans to enameled No. 25 cans, it was necessary to evaluate the conceivable effect upon the flavor of the product. Various abusive storage conditions were employed, but the most extensive flavor comparisons were made after 4 days' storage at 40° F. The results obtained by one taste panel indicated a statistically significant preference for the product packed in plain Common Coke cans. However, even this panel showed that the flavor difference was so slight that it was not always detected by a single person on direct comparison, and all tasters agreed that the difference was smaller than would be encountered in the normal daily variation in the flavor characteristics of the fruit employed. Three other panels were unable to detect a statistically significant difference.

The laboratory results were utilized in making semi-commercial tests and commercial tests before converting to full scale use of the No. 25 enamel lined cans. The semi-commercial test included 34,000 cans confined to two relatively small markets in Florida. The next step was a commercial test involving 2,400,000 cans shipped to major northern markets in the summer months. The results of these tests confirmed the laboratory findings by indicating the distinct superiority of the enameled No. 25 can over the plain Common Coke can in that it prevented completely the headspace discoloration without impairing product flavor or other attributes.

External corrosion. The large scale tests were also utilized to evaluate the factor of external rust on the outside of non-lithographed can ends. External organic coatings ordinarily had not been used on Common Coke ends. Outside plain and outside varnished No. 25 plate ends were compared with outside plain Common Coke ends. All cans tested showed slight rust on the end seam under the most adverse storage conditions, regardless of the tin coating and external varnish on the ends. However, No. 25 plate ends varnished outside were found to have a rust resistance equivalent to plain outside Common Coke ends under much more abusive conditions than ordinarily encountered. Inci-

dentally, it was found that an open ice cube compartment at 15° F. to 25° F. is slightly more conducive to external can rust than the general compartment at 40° F.

During distribution through 140 retail stores over a period of 80 days more than 1300 cans were examined individually in the retailers' cabinets and no rust was found on any area of any of the cans, even on the seams of the No. 25 end plate plain outside. Purchased samples were stored in 2 compartments of each of 7 styles of home refrigerators, including the humid cold-wall type. After 14 days no rust was found on the flat surface of the No. 25 ends varnished outside nor on the flat surface of the Common Coke ends plain outside. Traces to slight external rust was found on 18% of the flat surface of plain No. 25 outside ends. External seam rust was found on 64% of the No. 25 plain outside ends, 35% of the No. 25 varnished outside ends, and 29% of the Common Coke ends plain outside.

Tests on other citrus concentrates. After the initial laboratory tests with frozen orange concentrate, concurrent tests were made with other frozen citrus concentrates. Grapefruit concentrate and tangerine concentrate performed exactly like orange concentrate, showing the same type of black headspace discoloration of the product in plain tinplate cans closed with air in the headspace. However, the discoloration of lemonade concentrate, limeade concentrate, lemon juice and lime juice was much less intense, being tan instead of black. The use of enamel lined No. 25 cans prevented the discoloration of these products, too. The flavor difference that could be ascribed to cans was either imperceptible or insignificant.

In 1951 the complete conversion to enamel lined No. 25 cans for frozen citrus concentrates effectively combatted one of the effects of the adverse temperatures encountered during transportation, distribution, and home storage. During the ensuing years such temperatures have been improved very little. The use of the new container has not only met a need; it has also saved large quantities (about 85 tons) of strategic tin. Furthermore, the dollar savings due to the reduction in tin use have more than offset the cost of the organic coating. It has resulted in an overall reduction in the cost of the container.

Acknowledgment

In making the required experimental packs and evaluating the results, the authors and their associates received the generous cooperation of Birds Eye Division of General Foods Corporation, Libby, McNeill & Libby, Minute Maid Corporation, Pasco Packing Company and the University of Florida Citrus Experiment Station.

LITERATURE CITED

1. "Developments in Tinplate and Tinplate Manufacture in the United States During the Last Twelve Years." (A paper by R. H. Lueck and K. W. Brighton presented before the Second International Congress on Canned Foods, Paris, October 16-19, 1951).
2. Tin Mill Products, Section 14, *American Iron and Steel Institute Steel Products Manual* (June 1949).

A Study of Factors Affecting the Determination of Solids in Yeast Press Cake

R. F. DALE, JOSEPH AMSZ, JR., C. H. KEIPPER, E. J. COOPER, AND H. J. PEPPLER
Research Laboratories, Red Star Yeast & Products Co., Milwaukee, Wis.

(Manuscript received May 25, 1955)

An investigation of the effect of the addition of ethanol to yeast press cake, as recommended by the Association of Official Agricultural Chemists (1), revealed higher solids values than observed in untreated samples. Experiments with C^{14} labeled ethanol indicated that the alcohol is adsorbed and/or interacted with some yeast constituent to produce a non-volatile substance. Three satisfactory methods for determining solids in yeast press cake are given.

During a material balance study it was observed that yeast solids determined for a press cake (28-33% solids) exceeded those recovered from the same sample reconstituted to a cream (14-18% solids). Preliminary experiments established the validity of the yeast cream analysis method, therefore the method of analysis for press cake solids was examined critically. In this paper are presented the findings of an investigation of the official methods and a report of the effect of ethanol treatment on the analytical results. Three proven analytical methods for determining yeast solids in press cake and compressed yeast are described.

Both of the official analytical methods produced higher and more variable solids in press cakes than those predicted by analysis of corresponding cream samples. Since the only major differences between the two analyses are particle size and the use of additives (ethanol), the investigation was greatly simplified. First, it was necessary to reestablish the relation between yeast cream analysis and the official A.O.A.C. *(1)* and U.S.D.A. *(3)* procedures. Next, tests were conducted to determine the advisability of adding inactivators and, in so doing, to develop an acceptable press cake analysis procedure. Before accepting a new procedure, chemical techniques (carbohydrate analysis) were used to preclude the possibility of losses in this procedure due to autofermentation. As a last phase of the investigation, tracer techniques were used to confirm the presence of ethanol or an ethanol complex in the dry residue,* hence proving the inadvisability of this treatment.

EXPERIMENTAL

Drying equipment. It is our experience that the kind of drying oven greatly influences the uniformity and reproducibility of

* A similar effect has been noted and reported *(5)* for other food products.

solids values obtainable. Table 1, a summary of a study conducted in our laboratories, illustrates the superior performance of the horizontal forced draft oven. Additional data pertaining to the effect of temperature uniformity on moisture removal was reported by Fenske *(2)*.

A. O. A. C. test procedure (1). Place 5 g. of dry sand in weighing dish (minimum diameter 65 mm.), obtain tare weight including cover and stirring rod, and transfer 10 g. of slurry (3 parts water and 1 part press cake) to weighing dish. Cover and weigh to nearest 0.001 g. Add 5 ml. of alcohol and mix thoroughly with sand and yeast. Allow stirring rod to drop into weighing dish and dry 3 hours (±2 min.) at 105° C. Cover, cool in desiccator, and weigh.

U. S. D. A. test procedure (3). Place approximately 5 g. of compressed yeast in a tared metal dish provided with a cover and weigh. Add 8 ml. of 95% ethyl alcohol and mix thoroughly with a gentle rotary motion. Remove the alcohol on a steam bath. Dry 16 to 18 hours in an air oven at 100° C. Replace cover, cool in a desiccator and weigh.

In both above procedures—Formula 35A—(ethanol denatured with ethyl acetate) was used unless otherwise stated.

Recommended analysis procedures:

1. Place 2 g. of yeast press cake in tared weighing dish (minimum diameter 50 mm. with tight fitting cover). Cover immediately and weigh to nearest 0.001 g. Remove cover and break up cake with spatula being careful to remove any particles adhering to the spatula with a camel hair brush. Place in 100° C. drying oven for 16 hours. Cover, cool in desiccator, and weigh.

2. Place 2 g. of yeast press cake in tared weighing dish (minimum diameter 50 mm. with tight fitting cover). Cover immediately and weigh to nearest 0.001 g. Remove cover and add 5 ml. of room temperature distilled water and mix thoroughly with a gentle rotary motion. Place in 100° C. drying oven for 16 hours. Cover, cool in desiccator, and weigh.

3. Place 2 g. of yeast press cake in tared weighing dish (minimum diameter 50 mm. with tight fitting cover). Cover immediately and weigh to nearest 0.001 g. Remove and add 5 ml. of boiling distilled water and mix thoroughly with a gentle rotary motion. Place in 100° C. drying oven for 16 hours. Cover, cool in desiccator, and weigh.

Carbohydrate analysis procedure (4). Dried residues from the various types of solids determinations were ground in a mortar to a fine powder. A weighed portion of the powder was suspended in water and diluted to a final concentration of 300 μg./ml. A 1.0 ml. aliquot was used to determine total carbohydrate with the anthrone reagent according to the method of Trevelyan and Harrison *(4)*.

Experimental tests with Carbon[14] labeled alcohol. A small amount of radioactive ethyl alcohol was prepared by anaerobic fermentation of C^{14} sucrose.[b] This preparation was diluted with unlabeled absolute ethanol to yield 5.0 ml. of a mixture at an activity of 5000 counts/minute/milliter. An aliquot (0.1 ml.) placed in the 100° C. forced draft oven for two hours showed no activity whatever, indicating that there was no non-volatile radioactive material present in the alcohol preparation. This labeled alcohol was then used to treat yeast press cake as recommended in the official methods.

[b] Obtained on allocation by the Atomic Energy Commission.

TABLE 1

Temperature uniformity within various types of drying ovens

Type of oven	Setting temperature	Max. variation between points on shelves of oven
	°C.	°C.
Force draft oven, horizontal air flow	105	0.5
Convection oven No. 1	105	12.5
Convection oven No. 2, with copper plate	100	7.0
Convection oven No. 3	105	14.5
Inexpensive force draft oven, vertical air flow	105	5.5

Preparation of samples for cross test between yeast cream analysis and press cake analysis. Place 150 ± 0.2 g. of yeast press cake in 800 ml. beaker and add known weight of distilled water. Stir until uniform suspension is obtained. Place approximately 2 g. of yeast suspension in tared weighing dish. Cover immediately and weigh to nearest 0.001 g. Remove cover and place in 100° C. drying oven for 16 hours. Cover, cool in desiccator, and weigh.

$$\text{Percent Solids of Cream} = \frac{\text{Final Sample Weight} \times 100}{\text{Original Sample Weight}}$$

$$\text{Percent Solids of Press Cake} = \frac{\text{Total Weight of Suspension} \times \text{Percent Solids of Cream}}{\text{Weight of Press Cake}}$$

RESULTS AND DISCUSSION

Cross tests made according to previously described methods reveal consistently higher values for solids from alcohol-treated press cake as compared to calculated press cake solids, based on the yeast cream solids analysis (Table 2).

When four other procedures for press cake analysis were compared to the official methods, three of these resulted in consistently lower solids values than the official method (Table 3). These same three procedures also gave values which agree closely with those obtained with the cream analysis procedure. Ethanol denatured with ethyl acetate (Formula 35A) was used for treatment of the majority of ethanol-treated samples; however, evidence presented in Table 3 and Table 6 precludes any detectable effect by the denaturant.

A comparison between the A. O. A.C. analysis

TABLE 2

Comparison between alcohol-treated press cake solids and cream analysis solids

Method	Solids of yeast press cake plus ethanol	Solids by yeast cream analysis	Calculated press cake solids[1]	Difference between two methods[2]
	%	%	%	%
Test 1	31.5	18.4	28.7	2.8
Test 2	31.6	15.4	28.8	2.8
Test 3	31.9	18.2	29.4	2.5
Test 4	34.5	19.9	32.1	2.4

[1] Calculated as follows:

$$\text{Percent Press Cake Solids} = \frac{\text{Weight of Cream} \times \text{Percent Solids of Cream}}{\text{Weight of Press Cake Added}}$$

[2] Press Cake Solids—Calculated Press Cake Solids.

TABLE 3

Comparison of percent solids obtained by various analytical procedures

Method	Drying of untreated crumb	Drying of re-slurried crumb (cold water)	Drying of re-slurried crumb (boiling water)	Drying by USDA method[1]	Drying after addition of other inactivators	Calculated % solids from cream analysis
	%	%	%	%	%	%
Test 1	28.4	28.2	28.4	31.3	[2](Ac)–29.6 (12A)–31.2	.....
Test 2	28.2	28.2	28.1	30.7	(Ac)–29.5 (12A)–31.1	.....
Test 3	30.1	29.9	.....	31.9	.....	29.4
Test 4	33.4	32.6	.....	34.5	.....	32.1
Test 5	28.3	27.9	.....	31.1	(Ac)–30.4 (12A)–31.0	.....
Test 6	28.3	28.6	.....	30.7	.....	28.5
Test 7	28.6	29.0	.....	31.2	.....	.....
Test 8	28.7	28.7	28.6	31.5	.....	28.6
Test 9	28.6	28.6	28.8	31.9	.....	28.8
Test 10	28.0	.....	28.0	31.1	.....	28.0
Test 11	28.6	.....	28.1	29.3	.....	.....

[1] Inactivation by Formula 35A—ethanol.

[2] (AC) denotes acetone inactivator and (12A) is ethanol denatured with benzene (formula 12A).

method *(1)* and the overnight (16 hour) drying at 100° C. of untreated crumb was also made. Results (Table 4) show consistently high solids content on alcohol-treated samples, the same as observed by the U.S.D.A. procedure *(3)*. By this method, differences produced by alcohol treatment are smaller than those observed with the U. S. D. A. procedure, probably due to the higher drying temperature (105° C.), specified for the A. O. A. C. method. The duplicate tests exhibit poor checks on the alcohol-treated crumb.

TABLE 4

Comparison of solids by recommended procedure and A. O. A. C. procedure

Method	Overnite at 100° C. Drying of crumb		Difference between replicate analysis	Drying of crumb by A.O.A.C. Procedure		Difference between replicate analysis
	Test 1	Test 2		Test 1	Test 2	
	%	%	%	%	%	%
Sample 1	31.11	31.14	0.03	32.12	.....	.....
Sample 2	28.95	28.90	0.05	29.77	30.12	0.35
Sample 3	29.12	29.12	0.00	29.87	30.36	0.49
Sample 4	29.97	30.06	0.09	30.97	31.30	0.33
Sample 5	29.88	29.95	0.07	31.12	31.20	0.08

A difference of 2 to 3% in solids values is also noted on samples with and without alcohol-treatment when analyzed by a fast solids procedure. This method, currently under development, will be described at a later date.

Before adopting any of these methods it was felt advisable to determine whether autofermentation might be producing fallacious results. Carbohydrate analyses of the dry residue obtained by different treatments indicated that autofermentation was not an interfering factor in the yeast solids determinations (Table 5).

Throughout these tests it will be noted that all alcohol-treated samples yield higher solids analysis. The carbohydrate tests seem to confirm the fact that ethanol is adsorbed and/or reacted with some yeast constituent to form a relatively non-volatile compound. Taste tests made on the dry residue also show a pronounced off flavor, suggesting some change in composition induced by alcohol treatment, as noted in Table 5.

The volatility of the added alcohol was further checked by using radioactive alcohol in the U. S. D. A. test procedure *(3)*. These findings (Table 6) further confirm the suspicion that alcohol is adsorbed and/or reacted with some yeast component. As much as a four-fold quantity of labeled ethanol produced no increase in count in the dry residue. It is apparent that the minimal quantity tested saturated the yeast component involved

TABLE 5

Comparison between treatment, carbohydrate content and taste

Type of treatment	Solids (based on press cake)	Carbohydrate content of dry residue	Carbohydrate content adjusted for solids analysis (based on 28.8% solids)	Flavor of residue
	%	*mg./g.*	*mg./g.*	
1. Yeast Cake plus Ethyl Alcohol	31.9	200	222	Bitter-Strong Objectionable
2. Yeast Cake Dried, untreated	28.9	223	224	Normal pleasant nutritional yeast flavor
3. Yeast Cake plus boiling water	28.8	223	223	Same as (2)
4. Yeast Cake diluted to 17% cream	28.7	230	229	Same as (2)

and any variations observed between counts are within experimental error.

SUMMARY AND CONCLUSIONS

The treatment of compressed yeast cake (28-32% yeast solids) with ethyl alcohol as recommended by the A. O. A. C. and the U. S. D. A. for the determination of yeast solids introduced an error due to the adsorption and/or interaction of the alcohol and some yeast constituents.

Three methods of yeast solids analysis (recommended analytical procedures *1, 2,* and *3)* were found to yield results in agreement with those determined on yeast suspensions. All these methods in combination with a good lateral flow forced draft oven have yielded reproducible results.

Acknowledgments

We are indebted to Mrs. Claire Akemann and Mr. Peter Freund for their technical assistance during this investigation.

LITERATURE CITED

1. Association of Official Agricultural Chemists. *Official Methods of Analysis.* 1950, Washington, D. C.
2. Fenske, R. F. The determination of moisture in active dry yeast. (Thesis, Marquette University, 1952.)
3. Interim Federal Specifications, Yeast, EE-Y-00131a, 24 November 1954, par. 4.3.3.1.
4. Trevelyan, W. E., and Harrison, J. S. Studies on yeast metabolism. I. Fractionation and microdetermination of cell carbohydrates. *Biochem. J.*, **50**, 298 (1952).
5. Jansen, E. F., Waisbrot, S. W., and Rietz, Edward. Errors in the Zeisel methoxyl value for pectin due to retained alcohol. *Ind. Eng. Chem.*, **16**, 523 (1944).

TABLE 6

Results of solids analysis using radioactive absolute ethanol

Treatment number	1	2	3	4	5	6
Wt. of wet yeast, g.	2.0	2.0	2.0	2.0	2.0	2.0
Water added, ml.	.....	2.0	2.0	.....	.....	.....
C^{14} alcohol added, ml.	.....	.....	1.0	0.5	1.0	2.0
Solids after conventional 16 hours at 100° C., %	30.4	30.4	33.7	32.7	34.6	33.2
Residual C^{14} activity, counts/min.	.....	.....	250	250	290	230
Probable solids due to adsorbed ethanol, %	.....	.....	2.0	2.0	2.3	1.8
Corrected solids, %	30.4	30.4	31.7	30.7	32.3	31.4
Redried Aliquots [1]						
Solids after redrying, %	29.9	29.9	32.2	32.0	33.3	32.5
Residual C^{14} act., counts/min.	.....	.....	230	240	220	190
Probable solids due to adsorbed ethanol, %	.....	.....	1.8	1.8	1.7	1.5
Corrected solids, %	29.9	29.9	30.4	30.2	31.6	31.0

[1] Residue from first 16 hours was ground to powder and returned to the drying oven for an additional 17 hours at 100° C.

Antibiotics in Food Preservation[a, b, c]

L. LEON CAMPBELL, JR. AND R. T. O'BRIEN
State College of Washington, Pullman, Washington

(Manuscript received April 25, 1955)

A review of the literature on the application of antibiotics in food preservation.

Since the introduction of antibiotics as therapeutic agents, considerable interest has been aroused in the food industry as to the possibility of preserving foods with antibiotics. For convenience in considering the application of antibiotics in food preservation, the subject has been divided into four general categories: use in fresh foods; use in canned foods; action of antibiotics on food spoilage microorganisms; and the influence of antibiotics on the thermal resistance of spoilage bacteria.

FRESH FOODS

The potential use of antibiotics in the preservation of food was first studied by Curran and Evans *(17)*. In 1945, they noted that under suitable incubation conditions relatively low concentrations of penicillin had a sporicidal effect on several aerobic species of bacteria, including the thermophilic flat sour spoilage organism, *Bacillus stearothermophilus*. The sporicidal activity was more pronounced in milk than in water, and sublethal heating of the spores prior to the addition of penicillin usually enhanced the activity. In later papers *(18, 19)* they reported that neither penicillin nor streptomycin was a reliable agent for preserving milk, although penicillin at extremely low levels was sporostatic and sporicidal against a wide range of organisms. The greater efficiency of these antibiotics when used in conjunction with mild heat was again noted. Foley and Byrne *(26)* described the antibacterial action of penicillin on certain species of the natural flora of milk.

Tarr and his associates in a series of publications have reported on the use of antibiotics in the preservation of fish and beef *(10, 12, 59, 60, 61, 62, 63, 64)*. Experiments with penicillic acid *(59)* and later with streptomycin and penicillin *(61)* indicated that they had a negligible or feeble bacteriostatic action in fish stored at 32° F. (0° C.). Further studies with 15 antibiotics revealed that only aureomycin, terramycin, and chloromycetin were effective inhibitors of the natural mixed bacterial flora at temperatures between 32° F. (0° C.) and 69.8° F. (21° C.). Rimocidin inhibited yeast growth which often occurred in samples containing sufficient aureomycin or terramycin to suppress bacterial development. Aureomycin markedly inhibited spoilage when incorporated in minced fish or when steaks were immersed in solutions of the antibiotic *(62, 63)*.

Spoilage of whole eviscerated fish was significantly reduced by ices containing 1 to 4 p.p.m. of aureomycin, by holding the fish for 6 days at 30° F. (—1° C.) in sea water containing 2 p.p.m. antibiotic, or by immersion for 1 minute in solutions containing 50 to 100 p.p.m. aureomycin prior to icing *(64)*. Stability data on aureomycin and terramycin demonstrated that they are fairly stable in fish tissues stored for 2 days at 39.2° F. (4° C.). Marked destruction of both autibiotics occurred when heated at 212° F. (100° C.) for 30 minutes *(10, 64)*. Farber *(25)* presented data on the effect of aureomycin, terramycin and neomycin on the storage life of fish fillets and shrimp. Aureomycin and terramycin showed a definite preservative action when the fish were immersed in solutions of the antibiotic. Neomycin had no effect on the keeping quality of the fish, and none of the antibiotics was effective in the preservation of shrimp.

Deatherage, Weiser and co-workers have studied the use of antibiotics in the preservation of fresh beef *(30, 41, 68, 69)*. Only chloramphenicol, terramycin, and aureomycin successfully lengthened the keeping quality of beef *(30)*. These antibiotics also possessed high activity against a variety of microorganisms isolated from meat *(41)*. Aureomycin infusion of whole animals before dressing out prevented spoilage of the meat when refrigeration was delayed *(68, 69)*. The infused beef had a slightly altered appearance but from the standpoint of eating quality was indistinguishable from normal beef *(68)*. Data were also presented which indicate that aureomycin may delay spoilage in fresh pork sausage *(69)*. Hugli and Prudent *(32)* have found that subtilin does not prevent the red discoloration of ground meat containing nitrate, although streptomycin was effective to some extent.

Hounie *(31)* noted that ground meat inoculated with *Clostridia* species was effectively preserved for 5 or 10 days with a mixture of subtilin and streptomycin. Subtilin, streptomycin, or penicillin alone were less effective than the above mixtures while tyrocidin and chloromycetin were ineffective.

Kohler, Broquist, and Miller *(36)* reported that whole eviscerated or cut up chickens dipped in water containing aureomycin and stored at 40° F. (4.4° C.) remained fresh for 7 to 14 days longer than the untreated controls. This is in agreement with the findings of Ziegler and Stadelman *(75)* with chicken halves.

Subtilin has been found by Godkin and Cathcart *(28)* to retard the growth of *Micrococcus pyogenes* var. *aureus* and the natural heat resistant flora in custard fillings. A greater effect was obtained, however, when a combination of terramycin and subtilin was used.

---

[a] Scientific Paper No. 1409, Washington Agricultural Experiment Stations, Pullman. Project No. 1101.

[b] Supported in part by a contract with the U. S. Department of Agriculture and authorized by the Research and Marketing Act, 1946. The contract is being supervised by the Western Utilization Research Branch, Agricultural Research Service.

[c] Presented at The Puget Sound Section of the Institute of Food Technologists, February 26, 1955.

Combinations of aureomycin and terramycin retarded the growth of pathogenic micrococci but were ineffective against the non-pathogenic heat resistant flora responsible for spoilage. Subtilin was also effective in retarding the growth of food poisoning enterococci in custard fillings but a subtilin-terramycin combination was necessary to prevent growth of experimentally added strains of *Salmonella (29)*.

Smith *(57)* studied the use of streptomycin against soft rot bacteria responsible for the spoilage of fresh spinach. Dipping of fresh spinach in water containing streptomycin extended the shelf life at 70° F. (21.1° C.) for at least one day.

CANNED FOODS

Beginning late in 1949, a series of preliminary reports *(4, 5, 7, 8)* based on the work of Andersen and Michener of the Western Utilization Research Branch Laboratory, revealed that subtilin used in low concentrations and combined with mild heat exerted a marked preservative effect in a variety of canned foods. Their data *(5)* indicated that the spores of the most significant spoilage organisms, including *Clostridium botulinum*, were killed or effectively inhibited by the subtilin-heat treatment. These reports aroused considerable interest in the canning industry, since, if proven effective, safe, and practical, such a method would make possible the preservation of low acid canned foods without drastic heating. The use of antibiotics in preserving canned foods has been discussed by Cameron and Bohrer *(15)* and others *(9, 43, 44, 51, 53, 67)*. Cameron and Bohrer *(15)* have stated the requirements for establishing proof of the efficiency of an antibiotic as a preservative in canned foods.

Studies to confirm and extend the observations of Andersen and Michener have met with little success. Investigators at the National Canners Association Research Laboratory and associated workers have carried out extensive studies on the use of subtilin and other antibiotics as to their suitability for use in lowering the processing requirements of canned foods *(11, 13, 14, 15, 20, 21)*. Results of inoculated pack studies revealed that subtilin was generally ineffective in the preservation of a number of food products. Subtilin was apparently effective, however, in preventing or delaying flat sour spoilage of tomato juice *(13, 14, 20)*. Devlin *(23)* concluded from inoculated pack studies that subtilin was an effective adjunct to heat in the sterilization of pea puree.

Adams, Ayres and Tischer *(1, 2)* found that subtilin in combination with mild heat had limited value in preserving comminuted meat in sealed tubes inoculated with Putrefactive Anaerobe 3679 (P. A. 3679). Spilde *(58)* also noted that canned fish balls could not always be successfully preserved with subtilin.

Evans and Curran *(24)* studied the preservation action of subtilin and mild heat in normal and concentrated milk. Spoilage consistently occurred in milk inoculated with important food spoilage organisms at relatively high subtilin levels. They concluded that the subtilin-heat process was not a safe or effective method for preserving these products.

Before antibiotics can be safely applied in the preservation of canned foods, much information is needed on the adaptation of spoilage organisms to the antibiotics or combinations of antibiotics used. The ability of organisms to undergo selecttive adaptations is well known. In the case of subtilin, Salle and Jann *(56)* and McVeigh and Nobdy *(45)* have shown that several varieties of bacteria develop a resistance to subtilin after exposure to sublethal concentrations of the antibiotic.

There is rather general agreement that at this time there is no antibiotic which shows promise as a substitute for heat processing of canned foods. The Food and Drug Administration has ruled against the use of antibiotics in the preservation of food for human consumption *(27)*. Welch *(70)* has recently stated that "the presence of antibiotic drugs in food intended for human consumption, or the direct or indirect addition of such drugs to such foods, may be deemed an adulteration within the meaning of Section 402 of the Food, Drug and Cosmetic Act. It is unlikely that the position will be changed unless the evidence shows that the use of these drugs as preservatives in a given food is safe and is essential to the production of the food."

ACTION OF ANTIBIOTICS ON FOOD SPOILAGE BACTERIA

Stimulated by the reports of Andersen and Michener *(4, 5)* and Andersen *(3)* numerous papers have appeared on the action of antibiotics on important food spoilage organisms. Andersen and Michener *(4)* reported that in the presence of 0.4 p.p.m. subtilin, spores of *Cl. botulinum* suspended in water and heated at 190.4° F. (88° C.) for 10 minutes were destroyed or rendered highly sensitive to subtilin. Andersen *(3)* reported that 8 strains of *Cl. botulinum* and P. A. 3679 were sensitive to low subtilin concentrations in a medium which supported rapid germination. He suggested that subtilin was probably not effective against many of the spores until the beginning of the germination process. Williams and Fleming *(72)* showed that strains of *Cl. botulinum* differ in sensitivity to subtilin in culture medium and concluded that subtilin was sporostatic rather than sporocidal for the test organism.

Andersen, Michener and Olcott *(6)* reported that penicillin and terramycin were active against *Cl. botulinum* 62A at 0.2 p.p.m.; subtilin at 1 p.p.m; chloramphenicol and methylol gramicidin at 5 p.p.m.; and aureomycin, laterosporin, actinomycin, thiolutin and nisin at 20 p.p.m. Twenty other antibiotics were inactive at 20 p.p.m. The results of Denny, Bohrer, and Cameron *(20)* show that the mesophilic bacteria, including *Cl. botulinum*, were more resistant to subtilin in combination with mild heat than were the heat resistant thermophilic types. Their data indicate that the action of subtilin is bacteriostatic for the most part. Subtilin was found to be relatively stable to heat, withstanding 30 and 60 minutes at 250° F. (121° C.) particularly at pH 4.8. Krasnow and Jann *(37)* reported that the spores of *Cl. botulinum* were inhibited by minimal concentrations of subtilin at pH ranges of 5.5 to 6.5 and 8.5 to 9.0 while in the intermediate pH ranges,

minimal concentrations of subtilin were ineffective.

Denny *et al. (21)* tested several antibiotics from plant materials *(16, 33)* against *Cl. botulinum*. None of the antibiotics tested below 100 p.p.m. was effective. Several unidentified antibiotics of Merck and Company also showed no activity against this organism, although one, numbered 52 R 4 400, was very inhibitory for both types A and B *(21)*.

Wynne and Harrell *(73)* reported that penicillin had no effect on the germination of spores of *Cl. botulinum* 62A or P. A. 3679. Wynne, Collier and Mehl *(74)* similarly could not demonstrate any effect of streptomycin on spore germination of P. A. 3679, nor could a sporicidal action be shown. Kaufmann, Ordal and El-Bisi *(34)* studied the activity of neomycin, celiomycin, streptin, circulan and several numbered antibiotics against *Cl. botulinum* type B and P. A. 3679. Neomycin appeared to be bacteriostatic for *Cl. botulinum*. None of the antibiotics, however, showed any activity against P. A. 3679.

Andersen and Michener *(4, 5)* reported that the spores of *B. stearothermophilus* 1518 and *B. thermoacidurans* 43P suspended in buffer were not greatly affected by subtilin at 212° F. (100° C.). In culture media, however, the antibiotic was effective, growth being prevented by less than 0.1 p.p.m. Williams and Campbell *(71)* demonstrated that subtilin was of unequal effectiveness with different strains of a large number of obligate and facultative thermophilic flat sour bacteria. The facultative types appeared to be more sensitive to the antibiotic than the obligate types. Desrosiers and La Baw *(22)* have also observed a wide variation in the susceptibility of strains of *B. thermoacidurans* to subtilin. Michener *(48)* found that a stock of *B. stearothermophilus* 1518 contained a smooth and a rough component. A large proportion of the spores of the smooth component were dormant in tryptone broth and subtilin had no effect on these dormant spores. The spores of the rough component germinated quickly and the resulting vegetative cells were sensitive to the antibiotic. No evidence was found for a sporostatic action of subtilin with either the smooth or rough component. The bactericidal effect of subtilin, demonstrated by Sacks *(54)* for micrococci, was noted within a short time at 50 p.p.m. and in 48 hours with 5 p.p.m.

Kaufmann *et al. (34)* screened 9 antibiotics against several organisms associated with food spoilage. All of the antibiotics were sporicidal for *B. stearothermophilus* 1518 except one. Neomycin and celiomycin had a sporicidal effect against *B. thermoacidurans* 43P and exerted some sporicidal action against *Cl. thermosaccharolyticum*. None of the antibiotics, however, had any practical value in the control of flat sour spoilage in tomato juice *(35)*.

Michener *(47)* reported that if bacterial spores are heated in the presence of subtilin fewer can be detected by subsequent plating than if they had been subjected to an equivalent heat treatment in the absence of subtilin. No evidence of spore germination was seen and the treatment was effective under conditions which would not allow germination. It was incorrectly thought that the effect was not related to germination. Subsequently, it was found that subtilin increased the apparent death rate even when it was added as long as 20 minutes after the spores had been heated and cooled *(42)*. Michener later concluded that the antibiotic is adsorbed on ungerminated spores, but they are not affected until placed in an environment suitable for germination *(49)*. This is in agreement with the report of Mondolfo and Hounie *(50)*. Sacks *(55)* has reported, however, that subtilin can be sporostatic for a small proportion of the spores of *B. macerans*.

INFLUENCE OF ANTIBIOTICS ON THE THERMAL RESISTANCE OF SPOILAGE BACTERIA

LeBlanc *(39)* reported that subtilin greatly reduced the thermal resistance of spores of *Cl. botulinum* 62A and P. A. 3679 in pea puree, the degree of reduction being directly related to the concentration of subtilin employed. Devlin *(23)* confirmed these findings and extended the study to 6 other strains of *Cl. botulinum*. Spores of P. A. 3679 and *Cl. botulinum* 62A heated in purees of several foods containing 14.0 p.p.m. subtilin were found to be from 19 to 65% as resistant as they were in the absence of subtilin. LeBlanc, Devlin, and Stumbo *(40)* reported that subtilin materially reduced the resistance of spores of *Cl. botulinum* 62A and P. A. 3679 in pea puree. On the average, the resistance of P. A. 3679 spores, in the presence of 14.0 p.p.m. subtilin, was only 47% of the resistance of the spores in the absence of the antibiotic. Similarly, the resistance of *Cl. botulinum* was only about 63%.

Denny *et al. (21)* found that the thermal death rate of spores of P. A. 3679 in pea brine was not appreciably changed in the presence of tyrothricin, methylol gramicidin, rhatany root extract or subtilin. The thermal death rate of spores of *B. stearothermophilus* 1518 in pea or corn brine was apparently accelerated by these antibiotics with the exception that subtilin had no significant effect on this organism.

La Baw and Desrosier *(38)* reported that several edible plant extracts, in conjunction with mild heat treatment, reduced the heat resistance of spores of a flat sour organism. Lewis, Michener, Stumbo, and Titus *(42)* screened 67 antibiotics and a variety of other chemical agents for their ability to reduce the heat resistance of spores of P. A. 3679 and *Cl. botulinum*. Forty-seven of the antibiotics had no effect. Of the active antibiotics subtilin and nisin were the most effective in reducing thermal resistance of the test organisms.

Titus *(65)* found that time of contact with subtilin prior to heating had no effect on the thermal resistance of P. A. 3679 spores. Subtilin was more effective, however, when the spores were exposed to the antibiotic at 40° F. (4.4° C.) prior to heating than when exposed at 98.6° F. (37° C.). This could not be related to a more rapid germination at this temperature since Mehl and Wynne *(46)* have shown that germination of P. A. 3679 is faster at 98.6° F. (37° C.).

Titus and O'Brien *(66)* have demonstrated an apparent reduction in heat resistance of spores of P. A. 3679, *Cl. botulinum* (62A and 25B), *B. stearothermophilus* 1518 and *B. coagulans* 43P when heated in the presence

of subtilin or nisin. The apparent loss of thermal resistance was definite and reproducible under all conditions studied. These conditions included: pH range of 4.5 to 7.5, different recovery media, different suspending menstra, and different spore levels. Twenty-eight additional antibiotics, extracts or compounds were screened and none appeared effective. Thermal stability studies showed that 7.0 p.p.m. subtilin was stable up to 15 minutes at 270° F. (132° C.). Nisin was somewhat less stable although for this antibiotic the data were not complete due to the small amount of material available for testing.

LeBlanc *et al. (40)* reported that a limited number of experiments were conducted to determine if quantities of subtilin in the subculture medium, equivalent to those carried over by food samples containing 14.0 p.p.m. antibiotic, would inhibit spore germination or growth of the two organisms studied. Results of their limited studies indicated that the small quantities of subtilin did not detectably influence either spore germination or growth of vegetative cells of the test organism. More extensive studies on this point by O'Brien and Titus *(52)*, however, have clearly demonstrated that the carryover effect of 0.03 p.p.m. subtilin in the recovery media prevents the outgrowth of about 85% of the spores of P. A. 3679 surviving severe heat treatments. Outgrowth of heat activated spores was not materially affected by this concentration of antibiotic in the subculturing medium. Substantially the same number of spores was used in both experiments. Limited studies with *B. stearothermophilus* 1518, and *Cl. botulinum* 25B with 0.03 p.p.m. subtilin in the recovery medium and P. A. 3679 with 0.03 p.p.m. nisin showed similar effects. It is possible, therefore, that the apparent reduction in thermal resistance is due largely to the germination of the surviving spores with subsequent bactericidal action of subtilin. Much additional work is needed before the reasons for the differences obtained with severely heated spores and heat activated spores are known.

LITERATURE CITED

1. Adams, A. T., Ayres, J. C., and Tischer, R. G. The effect of subtilin and heat in preventing spoilage of comminuted beef. *Food Technol.*, **5**, 82 (1951).
2. Adams, A. T., Ayres, J. C., Tischer, R. G., and Ostle, B. Effect of subtilin on spoilage of thermal processed beef. *Food Technol.*, **6**, 421 (1952).
3. Andersen, A. A. Effect of subtilin on spores of *Clostridium botulinum*. *J. Bact.*, **64**, 145 (1952).
4. Andersen, A. A., and Michener, H. D. Effect of subtilin on bacterial spores. *Bact. Proc.*, p. 28 (1950).
5. Andersen, A. A. and Michener, H. D. Preservation of foods with antibiotics. I. The complimentary action of subtilin and mild heat. *Food Technol.*, **4**, 188 (1950).
6. Andersen, A. A., Michener, H. D., and Olcott, H. S. Effect of some antibiotics on *Clostridium botulinum*. *Antibiotics and Chemotherapy*, **3**, 521 (1953).
7. Anonymous, U. S. Dept. of Agr. Press Release. Antibiotics tested for preserving foods. (USDA 2765) Dec. 29 (1949).
8. Anonymous, U. S. Dept. of Agr. Press Release. Research shows antibiotic kills food organism. (USDA No. 1216) May 17 (1950).
9. Anonymous, Nonpharmaceutical uses of antibiotics. *J. Agr. Food Chem.*, **1**, 1096 (1953).
10. Bissett, H. M., and Tarr, H. L. A. Stability of antibiotic when used in experimentally retarding fish spoilage. *Prog. Repts. Pacific Coast Stations*, **93**, 23 (1952).
11. Bohrer, C. W. National Canners Association experimental program with subtilin. N. C. A. Information Letter 1325, 95 (1951).
12. Boyd, J., Brumwell, C., and Tarr, H. L. A. Aureomycin in experimental fish preservation. *Prog. Repts. Pacific Coast Stations*, **96**, 25 (1953).
13. Burroughs, J. D., and Weaton, I. E. Studies on the preservative action of antibiotics in processed foods. *Canner*, **112**, 50 (1951).
14. Cameron, E. J. Use of antibiotics in preserving foods. *Proc. Am. Meat Inst.*, **3**, 32 (1951).
15. Cameron, E. J., and Bohrer, C. W. Food preservation with antibiotics: the problem of proof. *Food Technol.*, **5**, 340 (1951).
16. Cavallito, C. J., and Baily, J. H. Antibacterial substances from *Asarum canadense*. *J. Am. Chem. Soc.*, **68**, 489 (1946).
17. Curran, N. R., and Evans, F. R. Penicillin as a sporicidal agent. *Proc. Soc. Exptl. Biol. Med.*, **58**, 262 (1945).
18. Curran, H. R., and Evans, F. R. The activity of penicillin in relation to bacterial spores and the preservation of milk. *J. Bact.*, **52**, 89 (1946).
19. Curran, H. R., and Evans, F. R. The activity of streptomycin in relation to bacterial spores and the preservation of milk. *J. Bact.*, **52**, 142 (1946).
20. Denny, C. B., Bohrer, C. W., and Cameron, E. J. National Canners Association experimental program with antibiotics. *N. C. A. Research Report 7-51* (1951).
21. Denny, C. B., Bohrer, C. W., and Cameron, E. J. National Canners Association experimental program with antibiotics (supplement of research report 7-51) Phase One and Phase Two. *N. C. A. Research Report 6-53* (1953).
22. Desrosier, N. W., and La Baw, G. D. Protecting tomato juice against flat sour spoilage. *Food Technol.*, **8**, 37, Abstract Section (1954).
23. Devlin, K. A. Subtilin as an adjunct to heat in food sterilization. (Ph.D. Thesis, State College of Washington, Pullman, 1953).
24. Evans, F. R., and Curran, H. R. The preserving action of subtilin and mild heat in normal and concentrated milk. *J. Dairy Sci.*, **35**, 1101 (1952).
25. Farber, L. Antibiotics as aids in fish preservation. I. Studies on fish fillets and shrimp. *Food Technol.*, **8**, 503 (1954).
26. Foley, E. J., and Byrne, J. V. Penicillin as an adjunct to the preservation of quality of raw and pasteurized milk. *J. Milk Food Technol.*, **13**, 170 (1950).
27. Food and Drug Administration. Statement of policy on antibiotics in foods. N. C. A. Information Letter 1427, 131 (1953).
28. Godkin, W. J., and Cathcart, W. H. Effect of antibiotics in retarding the growth of *Micrococcus pyogenes* var. *aureus* in custard fillings. *Food Technol.*, **6**, 224 (1952).
29. Godkin, W. J., and Cathcart, W. H. The complementary action of subtilin and terramycin in preserving custard fillings. *Food Technol.*, **7**, 282 (1953).
30. Goldberg, H. S., Weiser, H. H., and Deatherage, F. E. Studies on meat. IV. The use of antibiotics in preservation of fresh beef. *Food Technol.*, **7**, 165 (1953).
31. Hounie, E. Possibility of using antibiotics in the preservation of canned meats. *Food Manuf.*, **25**, 508 (1950); *Food Sci. Abstracts*, **24**, 206 (1952).
32. Hugli, E., and Prudent, I. Effect of subtilin and streptomycin on the formation of nitric oxide hemochromogen in cooked ground fresh beef. *Food Technol.*, **6**, 129 (1952).
33. Jensen, L. B. and Co-workers, and Hess, W. R., Miller, W. A., and Sherman, J. E. Preservation of food products. U. S. Patents 2,550,253—2,550,269. (1951).
34. Kaufmann, O. W., Ordal, Z. J., and El-Bisi, H. M. The effect of several antibiotics on certain spore-forming organisms involved in food spoilage. *Food Research*, **19**, 483 (1954).

35. Kaufmann, O. W., Ordal, Z. J., and El-Bisi, H. M. The action of several antibiotics on the spores of *Bacillus thermoacidurans* in a tomato juice medium. *Food Research*, **19**, 488 (1954).
36. Kohler, A. R., Broquist, H. P., and Miller, W. H. Chlortetracyline and the control of poultry spoilage. *Food Technol.*, **8**, 19, Abstract Section. (1954).
37. Krasnow, I., and Jann, G. J. The effect of pH and heat on the activity of subtilin against spores of *Clostridium botulinum*. *Bact. Proc.*, **28** (1953).
38. La Baw, G. D., and Desrosier, N. W. Antibacterial activity of edible plant extracts. *Food Research*, **18**, 186 (1953).
39. LeBlanc, F. R. Influence of subtilin on the thermal resistance of P. A. 3679 and *Clostridium botulinum* 62A. (M.S. Thesis, State College of Washington, Pullman, 1951).
40. LeBlanc, F. R., Devlin, K. A., and Stumbo, C. R. Antibiotics in food preservation. I. The influence of subtilin on the thermal resistance of spores of *Clostridium botulinum* and the Putrefactive Anaerobe 3679. *Food Technol.*, **7**, 181 (1953).
41. Lepovetsky, B. C., Weiser, H. H., and Deatherage, F. E. A microbiological study of lymph nodes, bone marrow, and muscle tissue obtained from slaughtered cattle. *Appl. Microbiol.*, **1**, 57 (1953).
42. Lewis, J. C., Michener, H. D., Stumbo, C. R., and Titus, D. S. Additives accelerating death of spores by moist heat. *J. Agr. Food Chem.*, **2**, 298 (1954).
43. Lundberg, W. O., and Chipault, J. R. Recent advances concerning the stability of foods. *Food Technol.*, **8**, 541 (1954).
44. Magdonelle, F. L. Recherches sur l' activité antibiotique de la subtiline. *Compt. Rend. Soc. Biol.*, **145**, 1876 (1951).
45. McVeigh, I., and Nobby, C. J. Development of resistance by *Micrococcus pyogenes* var. *aureus* to antibiotics: morphological and physiological changes. *Am. J. Bot.*, **39**, 352 (1952).
46. Mehl, D. A., and Wynne, E. S. A determination of the temperature characteristic of spore germination in a putrefactive anaerobe. *J. Bact.*, **61**, 121 (1951).
47. Michener, H. D. Effect of subtilin on ungerminated bacterial spores. *Bact. Proc.*, p. 29 (1953).
48. Michener, H. D. The bactericidal action of subtilin on *Bacillus stearothermophilus*. *Appl. Microbiol.*, **1**, 215 (1953).
49. Michener, H. D. The action of subtilin on heated bacterial spores. (Unpublished data, personal communication, 1954).
50. Mondolfo, H., and Hounie, E. L' zaione degli antibiotici sulle spore. *Boll. Ist. Sieroterap, Milan.*, **30**, 176 (1951).
51. Morse, R. E. Canning with antibiotics—pro and con. *Food Inds.*, **22**, 1679 (1950).
52. O'Brien, R. T., and Titus, D. S. (Unpublished data.)
53. Olcott, H. S. Problems in the application of antibiotics to food processing. N. C. A. Information Letter **1325**, 102 (1951).
54. Sacks, L. E. Subtilin considered as a germicidal surface-active agent. *Antibiotics and Chemotherapy*, **2**, 79 (1952).
55. Sacks, L. E. Use of trypsin to demonstrate a sporostatic action of subtilin. *Bact. Proc.*, p. 34 (1954).
56. Salle, A. J., and Jann, G. J. Studies on subtilin fastness *in vitro*. *J. Bact.*, **55**, 463 (1948).
57. Smith, W. L. Streptomycin sulfate for control of bacterial soft rot of packaged spinach. *Phytopathology*, **42**, 475 (1952).
58. Spilde, O. The use of subtilin in canning. *Tids. Hemetikind*, **37**, 297 (1951). *Chem. Abst.*, **46**, 7672 ,1952).
59. Tarr, H. L. A. Chemical inhibition of growth of fish spoilage bacteria. *J. Fisheries Research Board Can.*, **6**, 257 (1944).
60. Tarr, H. L. A. Microbiological deterioration of fish post morten, its detection and control. *Bact. Revs.*, **18**, 1 (1954).
61. Tarr, H. L. A., and Deas, C. P. Action of sulpha compounds, antibiotics and nitrite on growth of bacteria in fish flesh. *J. Fisheries Research Board Can.*, **7**, 221 (1948).
62. Tarr, H. L. A., Southcott, B. A., and Bissett, H. M. Effect of several antibiotics and food preservatives in retarding bacterial spoilage of fish. *Prog. Repts. Pacific Coast Stations*, **83**, 35 (1950).
63. Tarr, H. L. A., Southcott, B. A., and Bissett, H. M. Experimental preservation of flesh foods with antibiotics. *Food Technol.*, **6**, 363 (1952).
64. Tarr, H. L. A., Boyd, J. W., and Bissett, H. M. Experimental preservation of fish and beef with antibiotics. *J. Agr. Food Chem.*, **2**, 372 (1954).
65. Titus, D. S. The effect of time and temperature of contact with subtilin prior to heating on the thermal resistance of spores of P. A. 3679. (M.S. thesis, State College of Washington, Pullman, 1954).
66. Titus, D. S., and O'Brien, R. T. (Unpublished data.)
67. Walder, W. O. Antibiotics and food. *Food*, **21**, 100 (1952).
68. Weiser, H. H., Goldberg, H. S., Cahill, V. R., Kunkle, L. E., and Deatherage, F. E. Observations on fresh meat processed by the infusion of antibiotics. *Food Technol.*, **7**, 495 (1953).
69. Weiser, H. H., Kunkle, L. E., and Deatherage, F. E. The use of antibiotics in meat processing. *Appl. Microbiol.*, **2**, 88 (1954).
70. Welch, H. The Food and Drug Administrations' position on the use of antibiotics on crop plants. *Food Drug Cosmetic Law Journal*, **9**, 245 (1954).
71. Williams, O. B., and Campbell, L. L., Jr. The effect of subtilin on thermophilic flat sour bacteria. *Food Research*, **16**, 347 (1951).
72. Williams, O. B., and Fleming, T. C. Subtilin and the spores of *Clostridium botulinum*. *Antibiotics and Chemotherapy*, **2**, 75 (1952).
73. Wynne, E. S., and Harrell, K. Germination of spores of certain *Clostridium* species with the presence of penicillin. *Antibiotics and Chemotherapy*, **1**, 198 (1951).
74. Wynne, E. S., Collier, R. E., and Mehl, D. A. Locus of action of streptomycin in the development of *Clostridia* from spore inocula. *J. Bact.*, **64**, 883 (1952).
75. Ziegler, F., and Stadelman, W. J. The effect of aureomycin treatment on the shelf life of fresh poultry meat. *Food Technol.*, **9**, 107 (1955).

Stability of Tomato Juice and Concentrates Held at Elevated Temperatures

MARVEL-DARE NUTTING, JEAN G. HARRIS, I. C. FEUSTEL, AND H. S. OLCOTT
Western Utilization Research Branch, Agricultural Research Service, United States Department of Agriculture, Albany 10, California

(Manuscript received April 30, 1955)

Comparisons of quality retention among several different concentrations of tomato products were made over a three-year period. Samples of 5.6% to 8.8% total solids changed less in flavor and color than those of 21.0% to 38.4% when held at elevated temperatures for varying periods of time. The retention of ascorbic acid was greater in the less concentrated products.

For the past ten years, tomatoes have been one of the most important vegetable crops grown in this country. Approximately 44% of the total tomato crop processed in the United States in 1953 was grown in California, concentrated and canned, and shipped east for remanufacture into soup, catsup, and other products. In order to increase savings in container, shipping, and warehousing costs that result from concentrating the product before canning, there has been an increasing demand for pastes of solids content higher than the 26% which was standard a few years ago. The interest shown by the Quartermaster Corps in the stability of concentrates suitable for military menus, and for reconstitution to a tomato juice, gave further impetus to this study. Such increases in solids content are accompanied by certain disadvantages from the standpoint of quality retention. This has been evidenced by the fact that the more concentrated products develop a brown discoloration and a scorched flavor during storage, particularly at elevated temperatures. These changes are accompanied by an accelerated loss of ascorbic acid *(7)*. In addition, the can-life appears to be shortened by more rapid detinning of the cans containing the more concentrated products.

A review of the literature provides information on some of the factors influencing color *(6, 10, 18)*, consistency *(8)*, quality *(11, 12, 13, 17)*, and vitamin C content *(7)* of tomato juices and pastes, but little has been done on flavor evaluation. The retention of a good tomato color, as well as good flavor, is paramount in importance, if the product is to be used for the manufacture of soup. However, color is not as important if the pastes are to be used for remanufacture in catsup and spaghetti sauces, where a slight amount of browning may not be objectionable, since here consistency is the more imporant quality.

EXPERIMENTAL

A study was made over a 2-year period on the following products

Series 1—1952
Packed in tin

% T. S.	Salt
6.9	+
21.0	+
29.3	0
38.0	0

Series 2—1952

A group		B group	
Packed in tin			
% T. S.	Salt	% T. S.	Salt
6.8	+	5.6	0
25.1	+	36.8	0
30.7	+		

Series 3—1953
Packed in glass, tin, or enamel

% T. S.	Salt
8.8	0
30.7[a]	0
38.4	0

The first two series were used for reconstitution and stability studies. Stability was based on results from the subjective evaluation of flavor and color and from ascorbic acid retention. The two variables investigated were concentration (ranging from 5.6% to 38.4% total solids), and holding temperature (37°, 77°, 90°, and 100° F.). The 1953 series involved a study of 3 types of containers (glass, tinned and enamel-lined tinned cans) in order to determine whether type of container affects stability. In this series, observations were also made on the relative amount of de-tinning which took place after holding the 3 concentrations at elevated temperatures, and on the pitting of the enamel-lined cans.

All three series were prepared and very generously supplied by one canning company in California. The samples had undergone similar treatment, with the exception of several which were packed with added salt during special runs for subjective appraisal. These were included in order to determine whether the addition of salt affected the keeping qualities of the products.

In general, the processing procedure was as follows: Tomatoes of the Improved Pearson variety were received at the cannery, washed in warm water, inspected, and trimmed. From the inspection belt, the material passed to a chopper and then directly to a tubular heater in which heating to 200° F. occurred within a few seconds. During this time pectic enzymes were rapidly inactivated. From the top of the heating chamber, the hot macerate went to a pulper and finisher (0.06-inch screen) which broke up the macerate and screened out seeds, skins, and cores. The juice was pumped into large steam-jacketed kettles and brought to a boil. In two runs, salt was added in the amount of 30 pounds per 600 gallons of juice (0.6% NaCl). At this point, the samples of single-strength juice were canned.

The remaining juice was concentrated in 3 operations. It first went through a double-effect evaporator with the first effect maintained at 190° F. and the second at 125° F. At this point, samples of 21.0% total solids were removed. Residence time in the evaporator was about 15 minutes. This partially concentrated material then passed through an "after-heater" which raised the temperature to 200° F. The concentrate was pumped to a tubular evaporator operating under reduced pressure from which it emerged at 194° F. after about 5 minutes, with a total solids content of 25.1%. Paste was further concentrated in the same equipment and samples taken of various total solids content up to 38.4%. All cans went into a continuous cooker which ran for 14 minutes at 216° F. They were then trayed or put into water at 68° to 70° F. for more rapid cooling.

[a] An additional appraisal was made on samples of this concentration packed in glass and stored in the presence or absence of light.

The 1953 series were hand-packed in 3 types of containers as follows: (a) Glass jars (No. 303-66-mm. closure) were preheated in a hot-water bath and filled with juice at 190° F. directly from the finisher. They were capped with enamel lids and air cooled. The two pastes were similarly packed. (b) Sanitary cans standard for tomato products (No. 2, body plain 1.25 lb. tin plate, end fruit-enameled 0.25 lb. tin plate) were filled with the juice and 2 concentrates, capped on the plant machine and put into the continuous cooker. (c) Containers originally designed for citrus products (No. 2, body and end citrus-enameled, inside seam striped, 1.25 lb. tin plate) were filled, capped and heat processed.

Analysis and Appraisal

All of the products were received at the laboratory a few days after processing and were held at the desired temperature. Samples of each concentration were analyzed immediately for total solids according to the vacuum-oven drying method *(1)*, for ascorbic acid *(9)* with 0.5% oxalic acid *(14)*, and for salt content *(1)*. In addition, subjective appraisals for flavor and color were carried out. In the 1953 series, copper *(16)* and iron *(1)* determinations were also made on the samples packed in each of the 3 types of containers.

The appraisals of the first 2 series of tomato products were concerned mainly with the flavor and color evaluation of different concentrations canned with and without salt and held at elevated temperatures. In order to present uniform samples to the panel of judges the concentrates were reconstituted to juices containing 6.8% solids, and salt added to 0.7% where necessary. These were prepared 2 to 3 hours before serving to allow adequate time for blending and cooling. The one exception was a juice of 5.6% total solids which was served as received.

The samples were tasted under a faint red light to avoid any influence of faded or darkened color on the flavor grading. Each judge was asked to score on a 1-to-7 scale, where 1 = *much off-flavor* and 7 = *no off-flavor*. In most cases, a block of 3 or 4 and sometimes 5 coded samples were given to 10 to 12 judges at 4 successive periods. Thus 40 to 48 judgments were obtained on each of the samples for the factors graded. Wherever possible a sample held at 37° F. was presented as a labeled control with an arbitrary score of 5 for flavor and color to provide a standard for comparison.

The color was graded separately under 200-watt tungsten lamps with daylight filters. The judges were asked to score the reconstituted juices: 1 = *brown red color* and 7 = *tomato red color*. Because of the confusion arising from the interpretation of *tomato red color* the appraisals of the second series of products after 20 weeks were scored for color with a labeled control = 5, with 1 = *darker than control*, 7 = *lighter than control*. It was felt that this would help to standardize the scores, since a darkening in color seemed to accompany a deterioration in flavor quality.

In 1953 the third series of appraisals was arranged in order to obtain information on the effect of type of container on stability of 3 tomato products held at elevated temperatures. At this point, a system of ranking which had been tried and found very satisfactory for other products was instituted. It is simple and provides a good degree of reproducibility. Bliss *(2)* has discussed some of the advantages of ranking over scoring. The judges were asked to rank a block of 3 or 4 samples of tomato juice for flavor: 1 = *least off-flavor* to 3 or 4 (depending on the number of samples presented at one time) = *most off-flavor*, and similarly for color: 1 = *deep clear red color* to 3 or 4 = *orange or brown red color*.

In order to further confirm the results of series 1 and 2, a cross comparison of several temperatures and concentrations of products from series 3 was also ranked. For this latter evaluation, an incomplete block design for 7 samples was used according to plan 11.8 of Cochran and Cox *(5)*. Four samples were tasted at each session. Each sample was tasted 4 times, but with each other one twice.

An analysis of variance and least significant difference was calculated on all data in order to determine whether there was significant difference among the treatments. For the scoring data (1952, Tables 1 and 2) the analysis was made on the judges' averages for the 3 or 4 replications. For the ranking data (1953, Table 3) all the individual ranks were used in the analysis. Modifications were made in the degrees of freedom to account for lack of independence in the ranks. The least significant differences were of the Scheffé type *(15)*, as described by Wood, Olson, and Nutting *(20)*.

TABLE 1

Series 1 (1952)—Scoring of tomato products[1]

Holding time	° F.	Flavor: Total solids content 6.9%	21.0%	29.3%	38.0%	LSD 5%
		Average scores				
Initial	.....	6.09	5.70	6.08	5.98	.89 NS
3 Weeks	37	4.59[2]				
	100	4.74	3.68	3.89		.83
12 Weeks	37	5.48				
	100	5.52	3.49	3.86		.93
	37			4.89[2]		
	77			4.89		
	100			4.31		.69 NS
31 Weeks	37	4.52[2]				
	100	3.95	3.46	2.42	2.37	.74
35 Weeks	37		3.37			
	77		3.16			
	100	4.59[2]	2.86			1.16
	37			4.74[2]		
	77			4.66		
	100			1.76		.64
		Color				
Initial	.....	6.07	4.85	6.06	6.08	.46
3 Weeks	37	4.69[2]				
	100	4.35	4.41	4.98		.30
12 Weeks	37	5.31				
	100	5.36	5.02	5.08		.76
	37			4.92[2]		
	77			4.87		
	100			4.63		.43 NS
31 Weeks	37	4.94[2]				
	100	5.28	4.54	2.05	1.56	.68
35 Weeks	37		4.15			
	77		4.25			
	100	4.83[2]	3.95			.45
	37			5.09[2]		
	77			4.91		
	100			1.80		.62

[1] All scores within blocks obtained at same appraisal. Each average from 10-12 judges, 4 replications. 1 = *much off-flavor, brown red color*. 7 = *no off-flavor, tomato red color*. NS indicates no significant differences among treatments within a block; LSD the smallest difference between two treatments that is significant, calculated by Scheffé method *(15, 20)*.

[2] Also served as labeled control.

RESULTS

The first series of tomato products included a juice with 6.9% total solids and a concentrate of 21.0%, processed with salt, plus a 29.3% and a 38.0% concentrate without salt (Table 1). The initial scores showed no significant difference in flavor or color of the juice and the reconstituted samples, with one exception. The color of the juice from the 21.0% concentrate was significantly different from the other 3 samples appraised in the same block. Subsequent appraisals showed that the flavor and color scores of the juice were in general higher than those of the concentrates in any one block, and that there was a downward trend in scores as temperature and concentration increased. With the decrease in color scores there was a progressive browning in the more concentrated samples. It must be kept in mind that direct comparisons are possible only in each block of samples compared at the same time. Deteriorative changes in flavor and color of any one concentration at one temperature throughout the several storage periods were not investigated.

TABLE 2

Series 2 (1952)—Scoring of tomato products[1]

Holding time	°F.	Flavor: Total solids content (A) 6.8%	(A) 25.1%	(A) 30.7%	(B) 5.6%	(B) 36.8%	LSD 5%
		Average scores					
Initial	.....	5.18	4.76	4.62	5.07	4.78	.77 NS
10 Weeks	37	4.74[2]		3.19			
	100	4.68		2.90			.73
	37				4.75[2]	2.48	
	100				4.43	2.10	.85
11 Weeks	100	4.79[2]	2.96	2.68			.60
15 Weeks	37	4.89[2]	3.56				
	100	3.89	2.70				1.05
	37				4.88[2]	3.22	
	100				4.28		.81
20 Weeks	37	4.98[2]					
	90	4.44	3.04	2.54			.86
28 Weeks	90	4.34[2]					
	100	3.68					.64
	37		3.71				
	90	4.35[2]	3.70				
	100		1.99				.72
	37				4.89[2]	3.04	
	90				4.73	2.00	
	100				4.34		.94
		Color					
Initial	.....	4.74	4.96	5.20	4.32	4.81	.54
10 Weeks	37	4.83[2]	3.99				
	100	4.88	3.84				.84
	37				4.96[2]	4.12	
	100				4.66	2.57	.50
11 Weeks	100	4.96[2]	4.05	2.95			.36
15 Weeks	37	4.81[2]	4.01				
	100	4.76	3.94				.78
	37				4.73[2]	4.11	
	100				4.99		.56
20 Weeks	37	4.81[2]					
	90	5.16	4.18	3.09			.62
28 Weeks	90	4.79[2]					
	100	4.40					.30
	37		4.61				
	90	4.94[2]	4.50				
	100		2.87				.45
	37				4.97[2]	4.20	
	90				4.98	3.15	
	100				4.92		.45

[1] All scores within blocks obtained at same appraisal. Each average from 10-12 judges, 4 replications. 1 = *much off-flavor, brown red color.* 7 = *no off-flavor, tomato red color.* NS indicates no significant differences among treatments within a block; LSD the smallest difference between two treatments that is significant, calculated by Scheffé method *(15, 20).*

[2] Also served as labeled control.

The initial ascorbic acid values, reported on the basis of 6.8% solids content, varied somewhat in the 5 samples, and showed a fairly steady decrease in all samples with time and temperature.

The second series of 1952 products included 2 groups: (A) composed of samples of 6.8%, 25.1%, and 30.7% total solids canned with salt and (B) of 5.6% and 36.8% total solids canned without salt. The appraisal scores for these two groups are given in Table 2 and show the same trend as the first series. Again there was no significant difference initially in the flavor and color scores of the juice and reconstituted samples, with one exception. The initial color of the 5.6% juice was scored significantly darker than two of the other samples appraised at the same time. Although as previously pointed out a direct comparison cannot be made of scores from different groups of appraisals, it appeared that the flavor and color for the single-strength juices had changed little after 28 weeks at 90° and 100° F. The lowering in scores for the high concentration pastes, however, was greater at elevated temperatures.

Throughout the experiments, no differences were noted in the keeping qualities of the salted *versus* the unsalted samples.

The initial ranking of the 1953 series of products which was done in blocks of three showed that the flavor of the juice from the plain tinned container received the first average rank while the color ranks given to the juice from the 3 types of containers were not significantly different (Table 3). On all subsequent appraisals at 13, 30, and 38 weeks at 77°, 90°, or 100° F. the juice from the plain tinned cans always received the first average rank in *both* flavor and color. There were no consistent differences in flavor among samples from the 3 types of containers for the 30.7% and 38.4% concentrations either initially or after storage. However, both concentrations of paste from the plain tinned containers received the first average rank in color for every appraisal except the initial evaluation. It should be noted that all glass containers for the experiments were stored in the dark.

A comparison of the flavor and color of 30.7% tomato paste (canned in glass) stored in diffuse light with that stored in the dark showed little difference after 6 months at room temperature (77° F.). After 12 months, there was a slight preference for the sample kept in diffuse light. Though neither sample was unacceptable when reconstituted and served as a juice, the sample held in the absence of light received many comments of "scorched" flavor, and the color was always ranked as "darkest."

A cross comparison of samples packed in tin (Series 3, 1953) was made on the 8.8% juice held at 4 different temperatures, the 30.7% concentrate at 2 temperatures, and the 38.4% at one temperature. The samples were ranked 4 at a time for flavor, as described under Analysis and Appraisal and the ranks were converted to a basis of 7 in order to make them comparable with the color data. There seemed to be no problem in ranking 7 samples for color; therefore, all were made at the same time. Table 4 shows the progressive degradation of flavor and color in the 8.8% sample at elevated temperatures after 38 and 52 weeks. The pastes were relatively poorer as the holding temperature was increased. The color ranks followed the same general trend for the 3 concentrations, with some deviation.

The ascorbic acid values for the 1953 series of tomato products showed the same decrease as the previous 2 series when time, temperature, and concentration were increased. Figure 1 shows composite curves for the 4 ranges of concentration from the 3 series of tomato products held at 100° F. Values for ascorbic acid retention at 37°, 77°, and 90° F. resulted in curves of the same shape.

A slight feathering was noted in the tin cans containing the single strength juice which had been held for several months at elevated temperatures. The higher concentration pastes, however, showed increased detinning of the container after several months at elevated temperatures. After 12 months at 90° F. there was little tin left on the container of 38.4% paste. The pitting

TABLE 3

Ranking of tomato products (1953)[1]

Holding time and temp.	Total solids content 8.8% Glass	Tin	Enamel	LSD 5%	30.7% Glass	Tin	Enamel	LSD 5%	38.4% Glass	Tin	Enamel	LSD 5%
	Average ranks				Average ranks				Average ranks			
Flavor												
Initial	2.58	1.33	2.09	.49	1.85	2.52	1.64	.56	1.78	1.94	2.27	.53 NS
13 Weeks												
90° F.	1.88	1.79	2.33	.62 NS	1.86	1.97	2.17	.58 NS	1.94	1.91	2.15	.53 NS
100° F.	2.53	1.58	1.89	.52	1.64	2.14	2.22	.47	.....	.....	.....	.....
30 Weeks												
77° F.	2.00	1.73	2.27	.56 NS	1.95	1.77	2.27	.49	1.77	2.23	2.00	.58 NS
90° F.	2.50	1.43	2.07	.56	2.21	1.46	2.33	.66	1.93	1.70	2.37	.70 NS
100° F.	.....	.....	.....	.....	1.88	2.00	2.12	.76 NS	.....	.....	.....	.....
38 Weeks												
90° F.	.....	.....	.....	.....	2.28	1.53	2.19	.58	.....	.....	.....	.....
Color												
Initial	1.82	1.88	2.30	.57 NS	1.91	2.33	1.76	.62 NS	1.72	2.43	1.84	.58
13 Weeks												
90° F.	2.39	1.30	2.30	.49	1.80	1.61	2.58	.51	2.06	1.48	2.45	.47
100° F.	2.58	1.25	2.17	.34	2.44	1.28	2.28	.46	.....	.....	.....	.....
30 Weeks												
77° F.	2.23	1.59	2.18	.39	2.15	1.87	1.97	.56 NS	1.86	1.72	2.42	.44
90° F.	2.36	1.59	2.05	.19	2.56	1.23	2.21	.35	2.80	1.22	1.97	.36
100° F.	.....	.....	.....	.....	2.33[2]	(1.00)	2.67	.28	.....	.....	.....	.....
38 Weeks												
90° F.	.....	.....	.....	.....	2.67[2]	(1.00)	2.33	.25	.....	.....	.....	.....

[1] All ranks within blocks obtained at same appraisal, each average from 8 to 12 judges, 3 replications. 1 = *least off-flavor, deep clear red color.* 3 = *most off-flavor, orange or brown red.*

[2] LSD calculated on 2 values, since the sample packed in tin was obviously different from the other two samples.

TABLE 4

Ranking of tomato products packed in tin (1953)[1]

Holding time	° F.	Total solids content 8.8%	30.7%	38.4%	LSD 5%
		Average ranks			
Flavor					
38 Weeks	37	2.06			
	77	2.06	3.74	5.82	
	90	2.82	5.26		
	100	6.24			1.40
52 Weeks	37	1.84			
	77	2.44	3.76	5.30	
	90	3.00	5.00		
	100[2]	6.64			1.34
Color					
38 Weeks	37	3.67			
	77	3.59	2.77	6.74	
	90	2.48	5.56		
	100	3.19			1.49
52 Weeks	37	2.44			
	77	2.11	2.75	6.08	
	90	2.86	4.94		
	100[2]	6.80			0.82

[1] All samples within blocks ranked 4 at a time in a 7-incomplete block design, for flavor, and ranks were converted to a basis of 7 to make them comparable with the color data. Color ranked 7 at a time. Each average from 9 to 12 judges, 4 replications for flavor, 3 for color.

[2] A sample packed in glass was used, since the samples packed in tin had been exhausted.

of the enamel-lined cans increased in a like manner with increased holding time at elevated temperatures.

The copper and iron analyses after 7 and 12 months' storage (Table 5) showed little variation from expected values, when allowance is made for the effect of concentration. The iron is less than 6 p.p.m. given by Chatfield *(4)* for raw tomatoes. The copper is well within the range of 0.6 to 2.3 p.p.m. given by Bohart *(3)* on 44 samples of raw whole tomatoes.

SUMMARY

Changes in the flavor, color, and ascorbic acid content of canned tomato products showed clearly the greater stability of the less concentrated materials. The subjective evaluations of the tomato products from 5.6% to 38.4% total solids consistently showed lower flavor and color scores in the more concentrated materials, accompanied by a lowering of the ascorbic acid content, as holding time and temperature were increased.

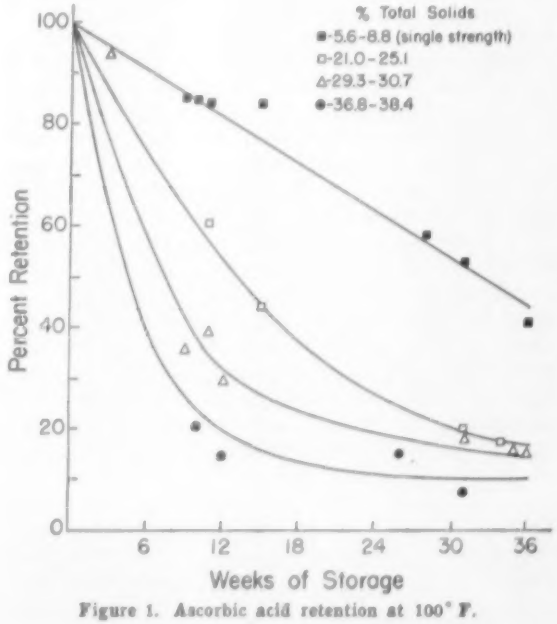


Figure 1. Ascorbic acid retention at 100° F.

TABLE 5

Analyses of tomato products

Holding time	Copper, p.p.m. Total solids content			Iron, p.p.m. Total solids content		
	5.8%	30.7%	38.4%	5.8%	30.7%	38.4%
7 Months, 77° F.						
Glass	1.2	6.1	9.9	4.9	14.0	15.2
12 Months, 90° F.						
Glass	2.0	5.0	6.7	5.1	10.8	15.9
Tin	1.6	3.6	7.4	3.0	8.3	22.6
Enamel	1.9	5.1	8.6	4.4	13.6	15.8

There was a tendency for the products from plain tinned cans to rank higher in both flavor and color than products packed in glass or in enameled cans. The concentrated pastes showed a progressive de-tinning of containers with increased holding time at 37°, 77°, 90°, and 100° F.

The copper and iron values determined after two periods of storage and on products from three types of containers were all within the normal range of values given in the literature.

Acknowledgments

The authors wish to express their thanks to members of the panel for their invaluable aid; to Elizabeth A. McComb and Earl F. Potter for the chloride, total solids, copper, and iron determinations; to the Thornton Canning Company for their cooperation in supplying and packing samples; and to Owens-Illinois Glass Company and American Can Company for containers.

LITERATURE CITED

1. Association of Official Agricultural Chemists. Official Methods of Analysis, 1950, 7th ed., Washington, D. C.
2. Bliss, C. I., Greenwood, M. L., and McKenrick, M. H. A comparison of scoring methods for taste tests with mealiness of potatoes. *Food Technol.*, **7**, 491 (1953).
3. Bohart, G. S. Studies of western tomatoes. *Food Research*, **5**, 469 (1940).
4. Chatfield, Charlotte. Food composition tables—minerals and vitamins—for international use. Food and Agriculture Organization of the United Nations, Rome, Italy, 117 pages (FAO Nutritional Studies No. 11) (1954).
5. Cochran, W. G., and Cox, G. M. *Experimental Designs*. 1950, John Wiley, New York, N. Y.
6. Friedman, M. E., Marsh, G. L., and Mackinney, G. On color in tomato products. *Food Technol.*, **6**, 395 (1952).
7. Hummel, Miriam, and Okey, Ruth. Relation of concentration of canned tomato products to storage losses of ascorbic acid. *Food Research*, **15**, 405 (1950).
8. Kertesz, Z. I., and Loconti, J. D. Factors determining the consistency of commercial canned tomato juice. New York State Agricultural Experiment Station (Geneva), *Technical Bull. 272* (March, 1944).
9. Loeffler, H. J., and Ponting, J. D. Ascorbic acid. Rapid determination in fresh, frozen or dehydrated fruits and vegetables. *Ind. Eng. Chem., Anal. Ed.*, **14**, 846 (1942).
10. Matlack, M. B., and Sando, C. E. Color in tomato products. *Fruit Prod. J.*, **13**, 81 (1933).
11. McColloch, R. J., Keller, George J., and Beavens, E. A. Factors influencing the quality of tomato products. I. Surface-localized pectic enzymes inactivated by blanching. *Food Technol.*, **6**, 197 (1952).
12. McColloch, R. J., and Kertesz, Z. I. Recent developments of practical significance in the field of pectic enzymes. *Food Technol.*, **3**, 94 (1949).
13. McColloch, R. J., Nielsen, B. W., and Beavens, E. A. Factors influencing the quality of tomato paste. II. Pectic changes during processing. *Food Technol.*, **4**, 339 (1950).
14. Ponting, J. D. Extraction of ascorbic acid from plant materials. Relative suitability of various acids. *Ind. Eng. Chem., Anal. Ed.*, **15**, 389 (1943).
15. Scheffé, Henry. A method for judging all contrasts in analysis of variance. *Biometrika*, **40**, Parts 1-2, 87 (1953).
16. Snell, F. D., and Snell, Cornelia T. Colorimetric method of analysis, Vol. I, 1944, D. Van Nostrand Co.
17. Underwood, J. C. Factors influencing quality of tomato paste. I. Chemical composition of California commercial tomato paste. *Food Research*, **5**, 366 (1950).
18. U. S. Quartermaster Food and Container Institute for the Armed Forces. The role of 5-hydroxymethylfurfural in browning. Project Report B909 (contract with Corn Products Refining Co.) (Oct., 1946).
19. U. S. Quartermaster Food and Container Institute for the Armed Forces. Browning in tomatoes. Project Report BB-3, No. 1, 5 pp. (contract with Continental Food, Inc. (July 1-Sept. 30, 1945).
20. Wood, Elizabeth R., Olson, Robert L., and Nutting, Marvel-Dare. A method for the comparison of consistency in potato granule samples appraised at different times. *Food Technol.*, **9**, 164 (1955).

A Recording Strain-Gage Denture Tenderometer for Foods. I. Instrument Evaluation and Initial Tests[a]

BERNARD E. PROCTOR, SOL DAVISON, GEORGE J. MALECKI,[b] AND MAY WELCH
Department of Food Technology, Massachusetts Institute of Technology, Cambridge 39, Mass.

(Manuscript received May 6, 1955)

A new method for objectively determining the tenderness of foods is described whereby quantitative evaluations are obtained in an apparatus fitted with human dentures, mechanically arranged to stimulate frequency and motions of chewing. The opposition to chewing motions caused by placing food between the teeth is rapidly and accurately indicated by strain gages of the electrical resistance type appropriately situated on the apparatus. The continuous amplified output from the strain gages during all portions of the chewing cycle is fed into a cathode ray oscilloscope, and traces on the face of the cathode ray tube are photographed with a Polaroid Land Camera. The precision of the strain-gage denture tenderometer is evaluated by observations of deflections obtained (1) when a calibrated mechanical spring is inserted in the apparatus and (2) when a pad of resilient sponge rubber is placed between the teeth with the mechanism arranged so that no destruction of the rubber occurs. Initial results obtained in tests on several foods and results obtained in comparison of the apparatus with a conventional mechanical instrument are reported. A general evaluation of the apparatus is presented, based on conclusions concerning data obtained.

Tenderness is an important feature of food quality. Food tenderness depends on the physical structural properties of the food itself, but the evaluation of food tenderness by the individual who eats the food depends to a great extent on his subjective interpretation resulting from his complex psychological and physiological reactions. Recent progress in the rheology of foodstuffs *(2, 3)* has aided considerably in clarifying the purely mechanical properties of stress and strain relationships in foodstuffs as they affect tenderness. In addition, extensive studies have been made relating to tenderness in respect to the normal changes taking place in plant and animal tissues under various conditions *(1, 6, 9)*.

Quantitative objective determination of tenderness is of great importance in the control of food quality. Instruments that determine tenderness, called tenderometers, have found application in fruit, vegetable, meat, bread, and other food industries and are used as a guide in the purchase of raw materials in the pea canning industry and in various food freezing industries.

Existing tenderometers determine tenderness on the basis of simple mechanical operations such as shearing, pressing, or puncturing. Because these operations deviate considerably from the complex operations that occur in the human mouth during the chewing process, incorrect interpretations of tenderness frequently result. A tenderometer in which the actual conditions of food chewing in the mouth are approximated should yield more meaningful tenderness data than an instrument in which such conditions are not approached.

Volodkevich *(7, 8)* has shown previously that measurement of the vertical force required to crush food with artificial teeth (or with rounded wedges) in a mechanical arrangement could be meaningful in determination of food tenderness. The force was measured mechanically on a recording drum coupled to the apparatus so that the horizontal deflection of the recording pen was proportional to the force of crushing, and the vertical movement of the drum was proportional to the distance between the crushing surfaces. The resultant plot was then correlated with structural properties of the food being crushed. Further experiments and improvements on the original apparatus, described by Krumbholz and Volodkevich *(5)*, enabled separate evaluations of crushing and shearing forces. These experiments have aided considerably toward determination of the important requirements of a tenderometer.

Certain features of the human chewing process are difficult to reproduce with an apparatus. These features include the complex movements and variations in force exerted by the lower jaw, the production of saliva and its mixing with food, and the complex movements of tongue, cheeks, and other fleshy portions of the mouth to move and position the food. Under different subjective conditions these three features are variable, and subjective evaluations of tenderness of a food vary from one person to another and may even be different with the same person at different times.

Significant information on the forces encountered in the chewing of foods by individuals has been obtained in dental studies by investigators at Tufts College Dental School in Boston, Mass. *(4, 10, 11)*. These studies were concerned with vertical bite forces exerted as maximum values and also those encountered in the chewing of different foods. Results were electronically measured by inductive-type strain gages held between the teeth or inserted in dentures of the individual.

Certain features characteristic of the chewing process can be simulated through mechanical and electronic means. This simulation has a certain quantitative significance characteristic of the tenderness concept experienced in the human chewing process. These features are (a) duplication of the chewing surfaces in the mouth through use of actual human dentures, (b) simulation of the frequency of the chewing cycles and the coordinated grinding and crushing motions of chewing, and (c) instantaneous transmission of forces encountered to a single point where they may be measured and recorded. This latter feature would be analogous to the instantaneous transmission of forces encountered by the jaw muscle in chewing.

[a] Contribution No. 254 from the Department of Food Technology, Massachusetts Institute of Technology.

[b] Present address: Green Giant Co., Le Sueur, Minn.

To incorporate these three characteristic features in an apparatus intended for objective determination of food tenderness, a tenderometer was constructed which utilizes a complete set of human dentures in a mechanical chewing arrangement (called a masticator) with provisions for variation of the motions. Forces encountered are measured by instantaneously recording the amplified output from strain gages appropriately placed on the apparatus. The inclusion on the apparatus of other features characteristic of human chewing, such as tongue movement and salivation, has not as yet been attempted. The importance of these features is recognized, as well as the additional complexities introduced when attempts are made to simulate them. The apparatus in its present state represents a step in the right direction, however, and offers a good basis for further investigation of additional features not yet incorporated.

DESCRIPTION OF APPARATUS

The electrical and mechanical connections of the tenderometer components are shown symbolically in a block diagram (Figure 1). The placement of the different parts of the apparatus as used in tenderness studies is shown in Figure 2.

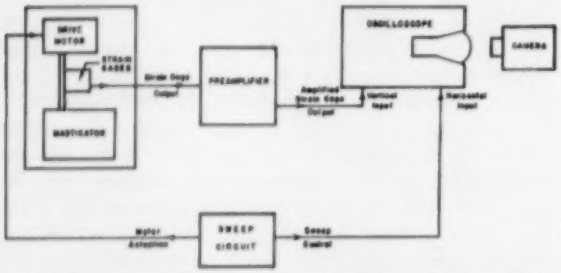


Figure 1. Block diagram illustrating electrical and mechanical connections of components of strain-gage denture tenderometer.

The food sample is first placed in the masticator, and a switch is closed to actuate the motor that drives the motion of the masticator. Changes in the resistance to chewing of the food encountered by the masticator are registered as changes in strain on a mechanical drive mechanism connecting with the masticator. These strains are translated by attached strain gages into changes in resistance, which are amplified as changes in potential and fed into the vertical deflection circuit of an oscilloscope to drive the electron beam vertically across the cathode ray tube. Simultaneously an electronic sweep mechanism is actuated, which feeds a time signal into the horizontal input circuit of the oscilloscope to drive the electron beam horizontally across the cathode ray screen. Hence the resultant trace on the face of the cathode ray tube has, as its vertical and horizontal coordinates, strain and time, respectively. The trace is photographed during the entire chewing operation by a camera attached to the oscilloscope.

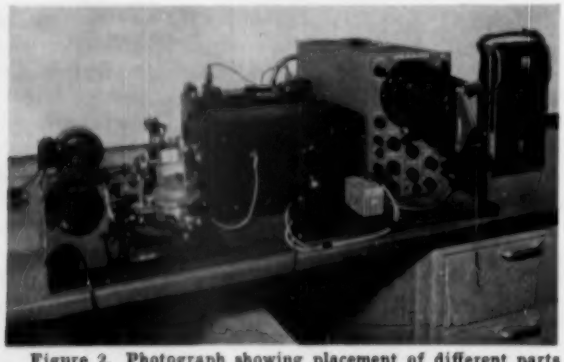


Figure 2. Photograph showing placement of different parts of strain-gage denture tenderometer.

Masticator and drive assembly. The masticator or chewing portion of the apparatus is designed to simulate chewing motion mechanically. This motion may be broken down into 3 basic motions of the lower jaw, (a) opening and closing or vertical motion, (b) lateral or sideways motion, and (c) forward motion. Control of these movements has been accomplished by mechanical adaptation of an articulator for continuous motion. An articulator is an instrument used in dental work to simulate jaw positions in the construction of human dentures.

The articulator used is a Hanau Model "H". It has ". . . adjustable condylar guides for protrusive and lateral excursions and an adjustable incisal guide, (and) enables accurate adjustments to mandibular movements equivalent to the functional masticatory movements of each patient." [c] Figure 3 shows how the articulator has been mechanically adapted for continuous chewing motions in determination of tenderness.

Plastic dentures (a, a) are fastened securely to the articulator with simulated cheeks, lips, and tongue built up from resilient plastic [d] material to keep the food located between the teeth during an experiment.

The movement of the articulator is actuated through a special transmission device connected with a geared-down electric motor. The articulator is free to swivel at point (c), and lateral movements are actuated by beam (d), whereas vertical movements are actuated by beam (e). Special springs (f) and (g) prevent development of excessive damaging pressure on the teeth by taking up excess forces on the beams, if they develop.

Adjustments have been made so that when the jaws are in the "fully closed" or "fully open" position, there is an open space (vertical) between the upper and lower first molars on the left side of 1 mm. or 22 mm., respectively. Hence the teeth surfaces do not actually meet during chewing. Contact of the chewing surfaces was purposely avoided to prevent complete shearing of the food on the first bite. Furthermore, it has been observed by Yurkstas and Curby *(11)* that " . . . the occlusal surfaces of the teeth rarely come into contact with each other during mastication."

The articulator has also been adjusted so that a lateral motion of about 2 mm. occurs during each chewing cycle. Adjustments available for variation of the motion are the left and right condylar adjustments (h, h), the left and right lateral adjustments (j, j), and the left and right centric adjustments (k, k).

The movement of the masticator is such that the upper jaw moves relative to the lower jaw instead of the reverse arrangement as in actual chewing. However, it is believed that this does not introduce error. The frequency of chewing was 45 cycles per minute.

Strain gages. The strain gages used are of the electrical resistance type (Baldwin SR-4; Type A-7; resistance in ohms, 120 ± 0.3; gage factor,[e] $1.94 \pm 2\%$; lot No. 232-11). This type of strain gage gives a change in electrical resistance proportional to the change in the strain in the member to which it is cemented. It appears to be well suited for this particular application, although Howell and Manly *(4)* report it to be inapplicable for use in the mouth in experiments involving chewing by actual patients.

The strain gage material is a copper nickel alloy with an inherently low temperature sensitivity. The gage grid has a length of about ¼ inch and a width of $\frac{7}{64}$ inch. The cement used for application is of nitrocellulose base.

Figure 2 shows the attachment of the strain gages (1, Figure 3) to the vertical movement beam. This system utilizes 2 gages mounted on opposite sides of the beam, so that the bending of

[c] From bulletin by Hanau Engineering Company, Inc., Buffalo 8, N. Y.

[d] Elastomer 105, Formulation 15-K; Elastomer Chemical Corp.

[e] The gage factor is a quantitative measure of change in resistance relative to change in strain. It is expressed in units of ohms per ohm divided by inches per inch.

Figure 3. Details of articulator of tenderometer showing its mechanical adaptation for continuous chewing motions. a, a, plastic dentures; b, plastic material; c, swivel point; d and e, beams activating lateral and vertical movements, respectively, of articulator; f and g, springs to take up any excess force on beams; h, h, condylar adjustments; j, j, lateral adjustments, and k, k, centric adjustments to vary lateral motion of articulator; l, strain gages; m, incisal pin.

the beam will produce a tension strain on one gage, at the same time producing a compression strain on the other gage. In this way the output potential of the combined system is twice that of one gage, since the resistance bridge circuit will be unbalanced in proportion to the difference in the strains applied to the 2 gages. Furthermore, the effect of temperature on the gages will be minimized, since increase or decrease of resistance caused by temperature changes will be practically the same on both gages. The beam is of wrought aluminum alloy (No. 245-T). The yielding force for this arrangement, based upon moment calculations using a yield strength of 43,000 lb./in.^{2}, is about 22 lb.

Pre-amplifier and oscilloscope. Figure 4 shows the wiring diagram of the strain-gage resistance bridge and the pre-amplifier. The pre-amplifier is used so that the changes caused by unbalance of the strain-gage bridge will give deflections on the cathode ray tube large enough for accurate measurements. As may be seen from Figure 4, the pre-amplifier has a balanced differential amplifier circuit for direct current. This type of amplifier has great advantage in that unwanted input common to both grids, such as power line noise, is rejected. The reference potential is maintained throughout at ground, and the filament voltage and plate voltage of the 6SN7 tube are supplied by batteries. The resultant arrangement is stable with respect to electrical and mechanical disturbances. Electrical balance is assured by periodic checks for zero potential across the grids and plates of the 6SN7 tube, and adjustment of potentiometers R_3 and R_8.

The cathode ray oscilloscope used for continuous measurement of the output potentials from the strain-gage bridge-amplifier sequence is a Dumont Model No. 304-A. This instrument has a sensitivity of 100 mv. D. C. full scale deflection, which is equivalent to a deflection factor of 25 peak-to-peak mv. per inch. The output of the pre-amplifier is fed into the balanced vertical input of the oscilloscope. The time signal is impressed upon the horizontal deflection circuit by means of a conventional RC time decay circuit shown in Figure 4. The focus of the electron beam is adjusted so as to produce a luminous spot of about 1 mm. diameter on the cathode ray tube. The coordinates of the spot on the tube face then correspond to the voltages impressed upon the vertical and horizontal input circuits. A voltage stabilizer (Raytheon VR 6114) is used to minimize effects from the possible line voltage variations that might occur during an experiment.

Variation of a sensitivity control on the oscilloscope enables a convenient method for study of different ranges of tenderness with maximum precision. Furthermore, the instrument can be standardized by adjusting the sensitivity control to obtain a definite deflection for a calibrated voltage input.

Camera. For permanent records, a camera adaptation has been made, which permits a finished record in a few moments. The moving spot on the face of the cathode ray tube can be made to leave a trace on a photographic film. A Fairchild oscilloscope camera assembly (Model No. F-284) utilizing a Polaroid camera, is used to record the oscilloscope traces. The short time (about one minute) required for developing of film proves to be of considerable advantage in examination of results.

PROCEDURE FOR MEASUREMENT OF FOOD TENDERNESS

Before each series of runs with food samples in the tenderometer, the amplifier is checked and adjusted for electrical balance, and the oscilloscope is adjusted so that the spot is on the left side of the screen. The shutter of the camera is then opened, and the mechanical movement is actuated by throwing switch S_6-S_9-S_7 (Figure 4), which at the same time actuates the horizontal sweep circuit so that the spot moves from left to right with a velocity governed by the choice of R_{16} and C_4 in the sweep circuit. Several cycles of "blank run" are obtained, and the food sample is then inserted. After the desired number of chewing cycles, the shutter of the camera is closed, switch S_6-S_9-S_7 is reversed, and the film is developed. The maximum deflections from the zero line in each cycle are measured.

All measurements are normalized to a standard blank run reading by use of the equation:

$$\text{Normalized deflection} = \text{Observed deflection} \times \frac{\text{Standard blank deflection}}{\text{Observed blank deflection}} \qquad \text{(Eq. 1)}$$

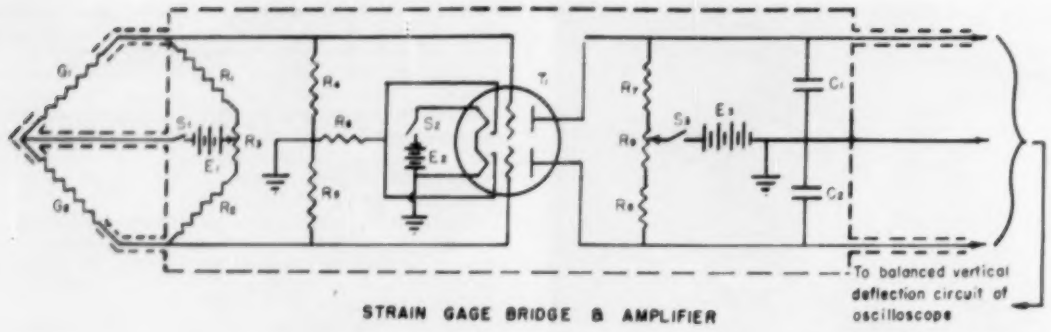
This normalization corrects readings for changes in overall sensitivity of the instrument in different runs. The normalized sample deflection minus the standard blank deflection is then recorded as the deflection caused by the presence of the food alone.

In some later measurements, correction for sensitivity of the instrument was made by means of a blank run on a calibrated spring. This gives a larger deflection than that occurring without the spring and reduces the error in the blank reading.

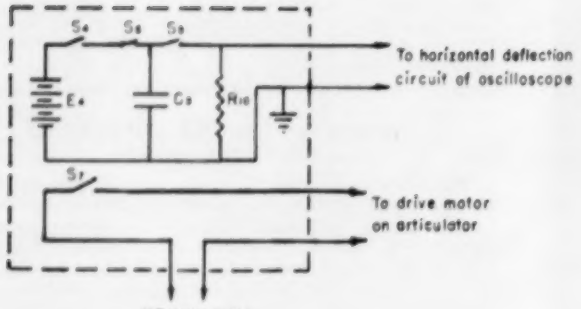
DETERMINATION OF PRECISION OF TENDEROMETER

Because of the variations in tenderness that may be found between different samples of the same type of food and even between different portions of the same sample, a meaningful evaluation of the precision of this instrument could not be made by repeated tests on a particular food. Instead it was decided to run repeated tests involving a known reproducible resistance to the chewing motion.

Two methods were utilized. In one method a metal spring was clamped between the moving members—actually attached to the incisal pin (m) (see Figure 3). The tension of the spring was adjusted by movement along the pin shown. In the other method a piece of firm sponge rubber was held between the teeth, with



STRAIN GAGE BRIDGE & AMPLIFIER



HORIZONTAL SWEEP CIRCUIT AND MOTOR POWER SWITCH

G_1, G_2	Strain gages (~120 ohms)
R_1, R_2	125Ω, 1% precision W.W.
R_3	2Ω, W.W. potentiometer
R_4, R_5	10⁵Ω, 1% precision W.W.
R_6	2500Ω, 1% precision W.W.
R_7, R_8	300KΩ, 1% precision W.W.
R_9	25KΩ, W.W. potentiometer
R_{10}	10⁶Ω, 1 watt carbon
E_1	6V. dry cell
E_2	6V. storage battery
E_3	180 V. dry cell
E_4	22·5 V dry cell
S_1, S_2, S_3	Ganged switch (3 sections)
S_4	SPST switch
S_5, S_6, S_7	DPDT, S_6 (N.C.)
T_1	6SN7
C_1, C_2	4 MFD, 350 Volts
C_3	100 MFD. 50 Volts

Figure 4. Wiring diagram of strain-gage resistance bridge, preamplifier, and horizontal sweep circuit.

adjustment made so that the rubber was not damaged during the chewing motions but merely compressed and returned to its original position and resiliency after each "bite." Numerous runs were made with the use of these two arrangements, and the results were analyzed to determine the instrumental limits of error in a measurement.

The use of the spring arrangement has proved highly valuable, as it lends itself to determination of the quantitative relation between the deflection obtained and the force applied. Measurements of the force required to compress the spring to the distance corresponding to definite deflections are easily determined experimentally by applying weights to the spring.

Table 1 summarizes data obtained from 20 runs with the calibrated spring and 20 runs with the sponge rubber pad. The first 20 cycles were measured in each run. The standard deviation of the deflections has been calculated for each run. The mean deflection for all 20 runs is 27.6 mm. in the steel spring experiments and 20.4 mm. in the sponge rubber experiments. The standard deviation of the means of the 20 runs is 1.07 mm. for the steel spring experiments and 0.34 mm. for the sponge rubber experiments. These standard deviations are larger than any of the standard deviations of the deflections in individual runs. The differences between the means of individual runs are attributed to differences in overall sensitivity of the instrument in the individual runs, and the mean deflections of these runs should be normalized to a constant value before a standard deviation is calculated on the basis of all the runs.

The standard deviations for each run normalized to the mean value of the 20 deflection means in each set of experiments are also shown in Table 1. The standard deviations are then calculated on the basis of the 400 deflections (normalized) obtained in both sets of experi-

TABLE 1

Results of precision tests with strain-gage denture tenderometer

Run No.[1]	Spring resistance (external to teeth)			Sponge rubber pad (between teeth)		
	Expt'l mean deflection (mm.)	Expt'l standard deviation (mm.)	Normalized standard deviation (mm.)	Expt'l mean deflection (mm.)	Expt'l standard deviation (mm.)	Normalized standard deviation (mm.)
1	26.0	0.24	0.26	20.9	0.17	0.17
2	26.2	0.14	0.14	21.0	0.00	0.00
3	26.2	0.16	0.17	21.0	0.05	0.05
4	26.2	0.21	0.22	20.8	0.15	0.15
5	26.4	0.19	0.19	20.6	0.21	0.21
6	26.4	0.19	0.20	20.5	0.14	0.14
7	26.8	0.18	0.19	20.4	0.11	0.11
8	26.9	0.24	0.25	20.4	0.12	0.12
9	26.9	0.11	0.12	20.6	0.15	0.15
10	28.1	0.13	0.13	20.6	0.20	0.20
11	28.2	0.09	0.09	20.5	0.14	0.14
12	28.2	0.13	0.13	20.4	0.17	0.17
13	28.1	0.10	0.10	20.0	0.08	0.09
14	28.2	0.23	0.22	19.5	0.17	0.18
15	28.2	0.13	0.13	19.4	0.10	0.10
16	28.5	0.20	0.20	20.5	0.17	0.17
17	28.4	0.12	0.12	20.4	0.19	0.19
18	28.8	0.22	0.22	20.5	0.16	0.16
19	28.8	0.20	0.19	20.4	0.13	0.13
20	29.1	0.13	0.12	20.3	0.26	0.26
Mean	27.6		0.18	20.4		0.16

[1] Twenty deflections were measured in each run.

ments. These standard deviations are 0.18 mm. and 0.16 mm., respectively. An error range for a single measurement may then be calculated. The limits of error at a 99.7% probability level for a single measurement are ± 3 (S. D.). On this basis, the following limits are calculated:

Experiment	Average deflection	Range of error at 99.7% probability level
Spring	27.6 mm.	± 0.54 mm. (2.0%)
Rubber	20.4 mm.	± 0.47 mm. (2.3%)

These ranges of error on a percentage basis are small and approach those of the reading error alone. The reproducibility of the behaviour of the mechanical and electronic components of the instrument, under conditions of nearly ideal (constant) input, is therefore almost as high as can be expected. Upon this basis it is possible to examine critically the results observed for actual foods.

TESTS ON VARIOUS FOODS

The strain-gage denture tenderometer has been used for objective tests of the tenderness of certain foods. All measurements on food samples were taken on the left side of the jaw. To obtain meaningful results, it was necessary to observe sample size carefully. Usually the samples were 1-cm. cubes. In comparative studies where units were small, as in the case of peas and corn, units of comparable size were selected. In certain cases where the chewing would cause pieces of the food to fall away from between the teeth and where information on more than one chewing cycle was desired, the samples were sealed in small polyethylene packages to maintain their position between the teeth. The size of the package was made large enough to prevent opposition to crushing by the plastic material. To avoid compression of air in the package, sealing was not air-tight.

Table 2 summarizes the initial results obtained with the strain-gage denture tenderometer on several foods, including apples (red side and green side), potatoes, mature and immature fresh peas, Bartlett pears, peaches (red side and yellow side), and bread. Several samples from each of several different items of each food were tested. The values recorded are those for the first bite only.

The standard errors calculated from observations (plus and minus standard deviation divided by square root of number of samples) made for each food item show that in almost all cases the dispersion of the deflections obtained is greater than that to be expected from the inherent precision of the instrument, as experimentally determined. Since the method of measurement was constant for all samples, the tentative conclusion may be made that the dispersion of results obtained for a single item was caused by measurable differences in tenderness in different portions of the same item. The differences in the results observed for different items of the same food were not unexpected, as various of these items apparently differ in tenderness from the standpoint of subjective evaluation. However, no attempt was made in this experiment to relate the instrumental measurements with subjective evaluations of the different food items.

TABLE 2
Results obtained for various foods with strain-gage denture tenderometer

Food	Item No.	No. of samples	Average deflection (mm.)	Stand. dev. (mm.)	Standard error	
					Absolute	Percent
Apples (red side)	1	7	16.8	6.14	2.32	13.8
	2	8	13.3	2.72	0.96	7.2
	3	8	16.8	2.46	0.87	5.2
	4	8	12.8	3.34	1.18	9.2
	5	6	13.2	2.96	1.21	9.1
	6	6	9.0	1.85	0.76	8.4
	7	6	6.8	0.61	0.25	3.7
	8	9	9.9	3.04	1.02	10.2
	9	8	9.7	2.79	0.99	10.2
	10	8	9.2	1.91	0.68	7.3
Apples (green side)	1	8	22.4	4.22	1.49	6.6
	2	6	14.5	1.85	0.76	5.2
	3	6	16.4	1.97	0.80	4.9
	4	8	11.1	3.44	1.21	1.1
	8	8	11.8	2.25	0.80	6.7
	9	8	10.9	3.03	1.07	9.8
Potatoes	1	8	22.8	3.75	1.33	5.8
	2	8	17.8	2.45	0.87	4.9
	3	8	20.7	3.32	1.17	5.7
Peas, mature fresh	1	8	22.6	2.57	0.91	4.0
	2	8	22.3	2.36	0.83	3.7
Peas, immature fresh	1	8	16.4	5.57	1.97	12.0
	2	8	11.7	4.69	1.66	14.2
Pears Bartlett	1	8	15.7	4.81	1.48	9.4
	2	8	15.1	3.40	1.20	7.9
	3	8	9.8	3.23	1.14	11.6
	4	8	7.6	1.56	0.55	7.3
	5	8	7.2	1.27	0.45	6.2
Peaches (red side)	1	8	4.4	1.65	0.59	13.3
	2	8	2.6	0.62	0.22	8.5
	3	8	2.3	0.67	0.24	10.3
	4	7	2.0	0.66	0.25	10.8
Peaches (yellow side)	1	8	3.2	0.57	0.20	6.3
	2	8	4.2	0.48	0.17	4.1
	3	8	2.2	0.60	0.21	9.6
	4	8	3.6	0.77	0.27	7.6
Bread	1	8	10.1	1.50	0.531	5.3
	2	8	13.4	2.87	1.01	7.6

Comparison with pea texturemeter. Comparison of results obtained by the strain-gage denture tenderometer with those obtained by an instrument of conventional design can be of great interest. Comparative studies were, therefore, made with a pea "texturemeter" (Wm. F. Christel Co.), designed to determine the texture of peas by measurement of the force required to press 25 cylindrical rods ($\frac{3}{16}$-inch diameter) simultaneously into peas confined in a metal cup (diameter 2 inches, height 1½ inches). In these tests thawed samples of the frozen variety of peas, corn, and baby lima beans were used. Figure 5 shows the relationship of readings obtained on both instruments for corresponding samples. Texturemeter readings are plotted as ordinates and corresponding tenderometer readings as abscissae. Each point corresponds to an average of about forty tenderometer readings (single peas used for each reading) and of about 4 texturemeter readings (about 50 peas used for each reading).

The numerical readings for both instruments vary in the same order, namely, baby lima beans > kernel corn > peas. However, the plotted values do not indicate a linear trend. This shows that there is a fundamental difference in the qualitative interpretation by the two instruments.

The increase in tenderness caused by cooking the

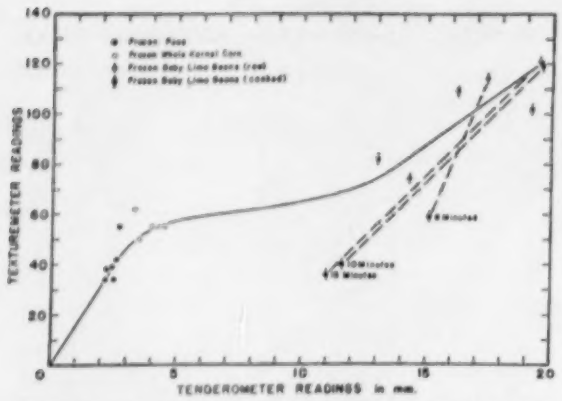


Figure 5. Comparison of tenderness measurements on vegetables made with strain-gage denture tenderometer and a pea texturemeter.

lima beans in water at 100° C. for different periods of time may also be seen from Figure 5. As shown by the readings for both instruments, the tenderness was greatest in the beans cooked for 15 minutes, less in those cooked for 10 minutes, and least in those cooked for 8 minutes.

Tests on bread. The strain-gage denture tenderometer was used in a series of experiments on bread stored for different periods under different conditions. A loaf of bread consisting of 16 slices (½ inch thick) was divided into 4 batches. The slices were selected so that no batch was appreciably different from the others in representation of the whole loaf. Batch (1) was left loosely covered with the original wrapping, at room temperature. Batch (2) was loosely covered with polyethylene wrap (punched with small circular holes) and stored in a refrigerator. Batches (3) and (4) were rewrapped in portions of the original bread wrapper, which were then taped at the seams. Batch (3) was kept at room temperature with batch (1), and batch (4) was kept in the refrigerator with batch (2). Each batch was weighed from time to time and the percentage loss in weight calculated. Tests were also made with the tenderometer at various times, 20 half-inch cubes being used for each test.

Tests commenced after 5 days of storage. At this time batch (1) was dry and cracked, too brittle to cube for testing. The results obtained for the other 3 batches are shown in Figure 6, where the percentage loss in weight is plotted as the horizontal coordinate. The days of storage are plotted corresponding to the left-hand vertical coordinate, and the tenderometer readings corresponding to the right-hand vertical coordinate. The hollow circles and squares represent the percentage losses in weight plotted with reference to the number of days of storage, and the curves have been based on these data alone. The solid circles and squares represent the percentage losses in weight plotted with reference to the tenderometer readings. The relative magnitudes of the scales of the right-and left-hand vertical coordinates were arbitrarily adjusted so that the percentage loss in weight as related to length of storage and the degree of tenderness could be graphically compared.

In general, the decrease in tenderness (as interpreted by the instrument) followed the increase in loss of weight of the bread (attributed primarily to loss of water). An exception was the tenderometer determination made on batch (3) when the loss in weight was in excess of 20%. The sudden decrease in the tenderometer reading for this sample was ascribable to the high brittleness of the bread, which reduced considerably the sustained force required for shearing.

EXPRESSION OF DEFLECTION MEASUREMENTS IN FORCE UNITS

The magnitude of the deflections of the strain-gage denture tenderometer was determined in terms of pounds of force. To accomplish this, experiments were conducted in which various weights were applied to compress the spring used in the precision studies to definite lengths. These weights were then compared with the deflections obtained when the spring was inserted in the tenderometer. These deflections were the normalized values corrected for a blank run and were calculated as in the actual tenderness studies.

It was found, as a first approximation, that each millimeter of deflection corresponds to a force of 0.25 lb. Therefore, the deflection values presented in this paper or various substances can be converted to force values by the expression:

$$\text{Force (lb.)} = 0.25 \times \text{deflection (mm.)}$$

SAMPLE OSCILLOSCOPE PHOTOGRAPHS

Figure 7 shows six sample photographs of traces made on the cathode ray tube of the oscilloscope during various experiments. As shown on the photographs, the Fairchild oscilloscope camera makes provision for

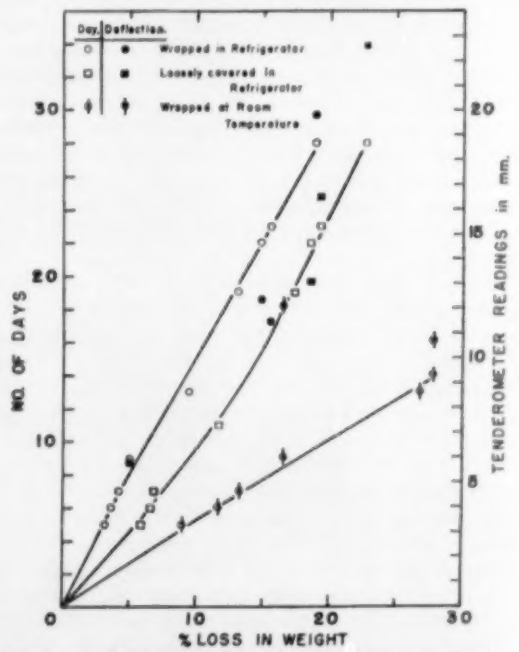


Figure 6. Curves showing relationship between length of storage and percentage loss in weight and plotted data showing relationship between percentage loss in weight and tenderness of bread samples.

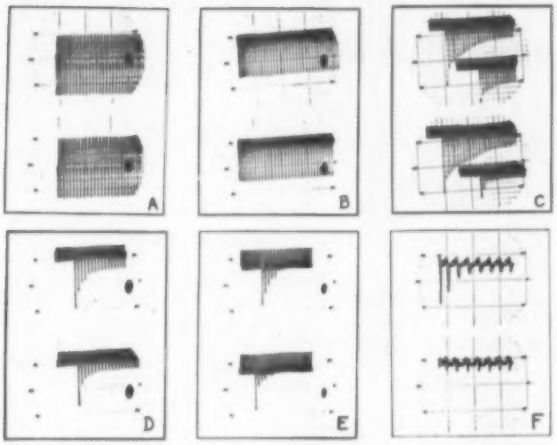


Figure 7. Sample photographs of traces on cathode ray tube of oscilloscope. Frame A, traces made with calibration spring; frame B, traces made with sponge rubber; frames C, D, and E, traces obtained with samples of fresh lima beans and fresh and frozen corn, respectively; frame F, traces showing effect of increasing horizontal sweep speed.

two exposures per frame of Polaroid film. Frames A and B show two traces made with the calibration spring and two with the sponge rubber, respectively, in the tests summarized in Table 1. Frames C, D, and E show traces obtained with samples of fresh lima beans and samples of fresh and frozen corn, respectively. The double traces in frame C were obtained by intentional double exposure of the film in these photographs. Frame F illustrates the effect of increasing the horizontal sweep speed so that details of the chewing cycle can be observed.

CONCLUSIONS

A primary problem confronting the food industry is the lack of an overall objective method for experimental determination of tenderness. As a result, a general standardization of criteria for tenderness measurements has not been developed. Therefore, a meaningful evaluation of the strain-gage denture tenderometer in terms of an existing reliable standard has not been possible.

The strain-gage denture tenderometer itself might conceivably aid in solving the problem of standardization of criteria for tenderness measurements and thus enable solution of other tenderness problems confronting the food industry. The initial tests on this instrument show that it has good potentialities for accomplishing this. These potentialities are based on several features of the instrument, as follows:

1. The instrument enables the approximate simulation of chewing motions and chewing surfaces, with provisions for adjustments enabling changes in frequency of chewing and in vertical and lateral movements of the jaw. In the experiments here reported, measurements have been evaluated for the first bite only. However, there is no reason why measurements for succeeding bites cannot be evaluated when the significance of these measurements has been sufficiently studied.

2. The instrument features an electronic method of force measurement by means of a strain-gage-oscilloscope arrangement. This arrangement enables good sensitivity and reproducibility, so that small samples may be used and small differences in applied forces detected. Furthermore, these forces may be recorded not only as maximum and minimum values but continuously throughout all portions of the chewing cycle. This arrangement differs from that of tenderometers of the conventional type in that it permits examination of the force exerted at any portion of the chewing cycle.

3. Essential portions of the equipment comprising the instrument are items of conventional design and are arranged so that mechanical and electronic modifications are easily made in investigation of special problems.

The instrument described in this paper is now under intensive experimental study, both in the development of fundamental research and in practical applications in determining the properties of tenderness of foods. This study requires correlation of instrumental results with subjective observations and physiological, morphological, and rheological knowledge of the substances examined.

Acknowledgment

The authors wish to acknowledge their gratitude to Dr. Rudolph Plank and his colleague Dr. N. N. Voldodkevich of the Technische Hochschule, Karlsruhe, Germany, whose pioneer efforts in 1938 stimulated interest in this field.

The authors wish also to express their deep appreciation to the individuals who have aided them in the problems encountered in the development of the strain-gage denture tenderometer described in this paper. These include Dr. R. S. Manly, Dr. A. A. Yurkstas, and their associates at Tufts College Dental School, F. H. McMillan, Jr., of the J. J. Crimmings Company (Boston, Mass.), W. G. Strovink of M. I. T., Dr. W. M. Murray of the Mechanical Engineering Department at M. I. T., and Francis Saunders of H. C. Baxter and Bros. (Brunswick, Maine).

LITERATURE CITED

1. Bate-Smith, E. C. The physiology and chemistry of rigor mortis, with special reference to the aging of beef. *Advances in Food Research*, **I**, 1 (1948).
2. Blair, S. *Foodstuffs, Their Plasticity, Fluidity and Consistency*. 1953. North-Holland Pub. Co., Amsterdam, and Interscience Pub. Inc., New York.
3. Frey-Wyssling, Albert. *Deformation and Flow in Biological Systems*. 1953. North-Holland Pub. Co., Amsterdam, and Interscience Pub. Inc., New York.
4. Howell, A. H., and Manly, R. S. An electronic strain gauge for measuring oral forces. *J. Dental Res.*, **27**, 705 (1948).
5. Krumbholz, G., and Volodkevich, N. V. Die Bestimmung der Fruchtfleischfestigkeit. *Gartenbauwissenschaft*, **17**, 543 (1943).
6. Lowe, Belle. Factors affecting the palatability of poultry with emphasis on histological post-mortem changes. *Advances in Food Research*, **I**, 203 (1948).
7. Volodkevich, N. N. Apparatus for measurements of chewing resistance or tenderness of foodstuffs. *Food Research*, **3**, 221 (1938).
8. Volodkevich, N. N. *Landwirtschaftl. Jahrb.*, **85**, Heft 5, 110 (1938).
9. Weier, T. E., and Stocking, C. R. Histological changes induced in fruits and vegetables by processing. *Advances in Food Research*, **II**, 297 (1949).
10. Yurkstas, A. A. Force analysis of prosthetic appliances during function. *New York State Dental J.*, **20**, 31 (1954).
11. Yurkstas, A. A., and Curby, W. A. Force analysis of prosthetic appliances during function. *J. Prosthetic Dentistry*, **3**, 82 (1953).

Potential Application of the Rapid Scanning Spectrophotometer for the Objective Valuation of Food Color[a]

REUBEN POMERANTZ,[b] SAMUEL A. GOLDBLITH, AND BERNARD E. PROCTOR
Department of Food Technology, Massachusetts Institute of Technology, Cambridge, Mass.

(Manuscript received February 14, 1955)

Color is often considered one of the most evident characteristics of food quality in both raw and processed foods. The methods of grading color most widely used at present in the food industry are subjective, since they require visual judgment by the naked eye. In view of the limitation in subjective color grading by the human observer, it is readily apparent that completely objective methods, using physical instruments, furnish the most reliable solution to color analysis of foods.

In view of the stress currently placed on the development of an instrument for physical determination of color whereby food colors can be graded objectively, an investigation was undertaken to evaluate the potentialities of the rapid scanning spectrophotometer.[c]

The data presented in this paper are in the nature of a preliminary, exploratory evaluation. Much more extensive investigation of each commodity, under various conditions, must be accomplished before the results reported may be recommended as positive tests for objective physical determinations of color. Rather than to perform a detailed study of any one food product, it was deemed more advisable to study only the overall potential of the instrument in relation to several different types of food. The several commodities selected were considered to be representative.

APPARATUS AND TECHNIQUE

The instrument used was equipped with reflection attachment (Figure 1). This instrument is a combination of an optical spectrophotometer and an electronic cathode-ray-tube indicating-device. Complete spectrophotometric curves in the visible region (400 to 700 μ) are instantaneously produced on the face of a cathode-ray tube. The coordinates for both the wavelength and the percentage of transmission are linear, and the illuminated grid (divided into wavelength intervals of 20 mμ and photometric intervals of 5% transmission) provides a convenient reference scale.

The detailed specifications for construction and operation of the rapid scanning spectrophotometer[d] are described elsewhere *(1)*.

The data produced on the face of the cathode-ray tube may be observed visually or, for permanent record, may be recorded photographically with a camera adaptable ot a 5-inch cathode-ray oscilloscope.[e]

For transmission measurements, the samples were placed directly into the cuvettes. The cuvettes were then placed in the cell holder, which in turn was placed inside the hinged door at the front of the instrument.

For reflectance measurements of opaque juices or semi-solids, a reflectance cell was required, but solid products such as bologna and peaches were placed in direct contact with the surface of the reflectance window.

All the samples utilized throughout this investigation were selected at random from shelves of food markets in the Boston-Cambridge area and were not in any case especially prepared by the manufacturer for this study. In the selection of the food products to be studied, special consideration was given to the following factors:

(1) importance of color in the grading of the product,
(2) tendency for the product to be adulterated,
(3) importance of color in specification purchasing,
(4) availability of a wide variety of commercial samples,
(5) existence of an official objective-type test, so that the rapid scanning spectrophotometer scores could be statistically correlated with scores obtained in accordance with the procedures prescribed in the current U. S. Government Standards.

Experimental plan and methods of evaluation. The experiments were divided into transmission and reflectance studies. The following food products were among those analyzed under the appropriate divisions:

Transmission Studies	Reflectance Studies
Olive oil	Tomato catsup
Maple sirup	Peaches
	Bologna

Transmission Studies. Seven brands of pure olive oil and in addition various brands of "salad oils" such as cottonseed oil, corn oil, peanut oil, and soybean oil, and mixtures of pure olive oil and their common adulterants were used in the transmission studies.

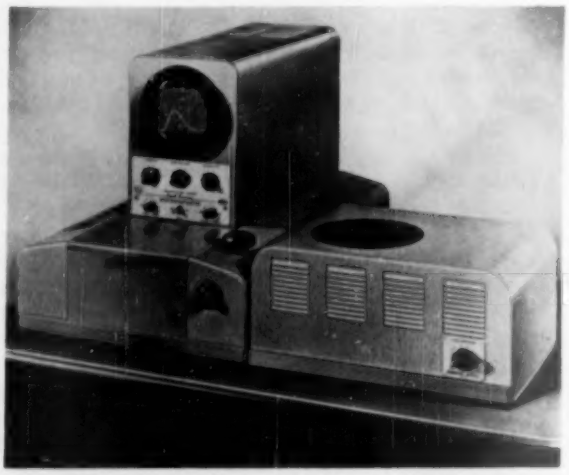


Figure 1. Rapid Scanning Spectrophotometer.

[a] Contribution No. 247 from the Department of Food Technology, Massachusetts Institute of Technology, based on a thesis presented in partial fulfillment of the requirements for the degree of Master of Science to the faculty of the Massachusetts Institute of Technology.

[b] Present address: Quartermaster Food and Container Institute for the Armed Forces, Chicago, Illinois.

[c] The authors are grateful to the American Optical Company of Buffalo, New York, for their generosity in loaning the Rapid Scanning Spectrophotometer for use in this investigation.

[d] Mention or discussion of manufactured products in the pages of this journal does not imply indorsement over other products in the same category. Ed.

[e] The camera utilized in this investigation was a Fairchild Polaroid Land Oscilloscope Camera.

The spectral transmission curves of several samples of pure maple sirup, labeled "Grade A," were compared with the spectral curves of 3 permanent amber glass standards.[f] In both instances, the curves were obtained with the rapid scanning spectrophotometer.

Reflectance Studies. In the reflectance studies with tomato products, all samples were graded, first, by an expert U. S. Department of Agriculture inspector. These same samples were then analyzed by the rapid scanning spectrophotometer, with the use of the reflectance cells. As reflectance measurements with tomato products of good color are relatively low at 550 mμ and relatively high in the region of 650 mμ, the ratio of percentage of reflectance at 650 mμ to that at 550 mμ was taken as the rapid scanning spectrophotometer score. Ten commercial brands of catsup were used to determine the relationship between the data obtained with the rapid scanning spectrophotometer and the data obtained by the grading method of the Official Production and Marketing Authority (PMA) *(17)*.

Ten commercial cans of halved clingstone peaches were also used for the reflectance studies. As there was a wide variety of color in the peaches within any one can, a total of 16 halves from the 10 different cans were used. The samples to be investigated were first graded by the U. S. Department of Agriculture inspector by means of prescribed Maerz and Paul plates *(11)*. Identical samples were then analyzed spectrophotometrically. The sirup was first drained from the peaches, and the samples were placed on the instrument with the outer surface in direct contact with the reflectance window.

To evaluate the rapid scanning spectrophotometer as an instrument for studying the effects of vacuum packaging and display case lighting on color retention of sliced meats, thin slices of bologna cut from the same 8-pound loaf were prepared in 6-ounce units as follows: (a) Flex-O-Vac (Vacuum sealed), (b) Pliofilm (heat sealed), and (c) unpackaged. The samples were stored at 40° F. and exposed to the light of two fluorescent lamp tubes for approximately 12 hours each day of the test. Samples of each type of packaged bologna were withdrawn from storage at regular intervals, and the discoloration was investigated by means of reflectance measurements. Each package was opened immediately prior to the reflectance measurement, and the entire contents were placed directly upon the surface of the reflectance window. The spectral curve was first recorded for the surface that had been exposed to the light and then for the under side, which had been completely protected from light. The score system employed in this analysis was that proposed by Kraft and Ayres *(8)*. The scores for the samples were assigned according to values obtained for the ratio of spectral reflectance at wave lengths of 650 mμ and 570 mμ.

OBSERVATIONS ON SELECTED PRODUCTS

Olive oil. Because of its relatively high price and great demand, olive oil is liable to be adulterated with other lower priced edible oils. The value of olive oil is largely dependent on its color as well as its taste, and the color of genuine olive oil obtained from ripe, hand-picked olives varies from a pale yellow to a golden color. The oils of lower grades, which are produced from a second pressing after the residue of the first extraction has been ground and mixed with water, may contain enough dissolved chlorophyll to impart a distinctly greenish tinge. The blending of lower grades of cheaper olive oil with accepted premium grades of olive oil is definite aduleration, but detection of this form of adulteration by present methods of analysis is almost impossible. Woodman *(19)* has stated:

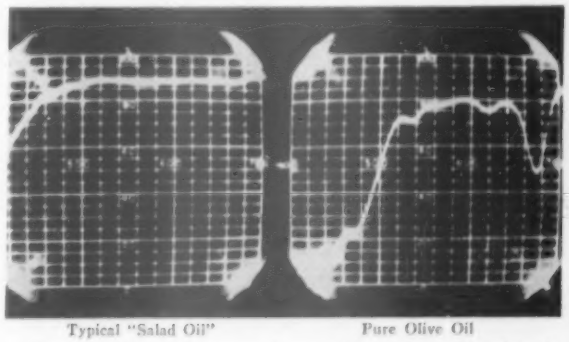
> "It has been not uncommon to find containers which originally contained genuine olive oil used again with 90% cottonseed oil to take advantage of the original labeling and general appearance."

As indicated in Figure 2, the spectral curve for the pure olive oil samples has definite characteristics, which are not present in the lower priced "salad oils."

For all the brands of pure olive oil tested, the spectral curves showed their principal characteristic maxima and minima at almost the same wavelength, but the intensity of transmission at this critical wavelength varied with the different brands. It is believed that the variation in the intensity of the peaks in these curves was related to the degree of refinement and the number of pressings that the olives had undergone. It was also apparent that the domestic olive oils, usually more highly refined than imported products, produced spectral curves with less intensity at their maximum and minimum points.

The effect of adulteration of pure olive oil with "salad oils" is indicated in Figure 3.

The rapid scanning spectrophotometer appears to



Typical "Salad Oil" Pure Olive Oil

Figure 2. Spectral curves of pure olive oil (right) and typical "salad oil" (left). (These data were recorded photographically, directly from the face of the cathode-ray tube.)

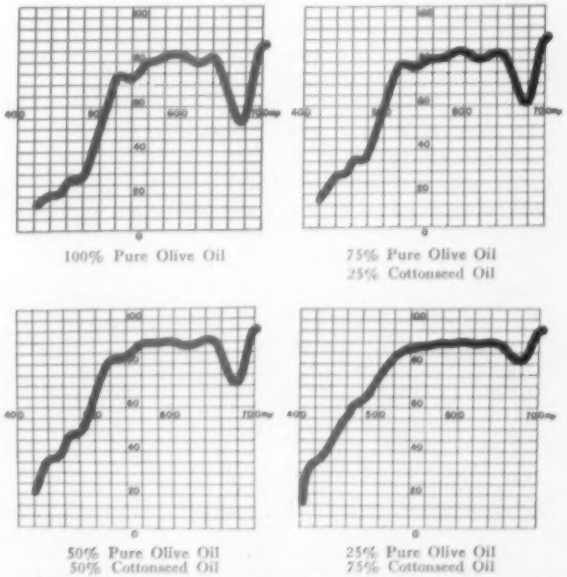


Figure 3. Effect of adulteration of pure olive oil with "salad oils."

[f] These standards, components of the Phoenix Color Comparator Set, were obtained from the Phoenix Instrument Company.

possess a high degree of potentiality for use in the olive oil industry. Although this instrument may not be universally adaptable to detect positive adulteration of any pure olive oil, it can readily detect the adulteration of any given sample of known quality or purity, once the standard spectral curve for the 100% pure product has been determined. In this respect the instrument should prove valuable in the quality control of bulk imports of foreign olive oil, which are shipped to this country for bottling and canning. The spectral curves can be utilized as a rapid index of the continuous quality and purity of any given brand. If a doubt is raised by this preliminary evaluation, the evidence can be confirmed by carefully detailed qualitative and quantitative analyses.

Maple sirup. The color of maple sirup has long been an important factor in the grading of this widely used table sirup, which is presently graded by use of color standards designated as light amber (Grade AA), medium amber (Grade A), and dark amber (Grade B).[8] The spectral curves of these three major standards obtained by use of the rapid scanning spectrophotometer are shown in Figure 4. The spectral curves for two samples of pure maple sirup labeled Grade A were compared with the spectral curve for the Grade AA (light amber color) standard. In accordance with these spectral transmission curves, Sample I (D) was graded AA (Fancy) with respect to color, whereas Sample II (E) was graded as meeting the color requirement for Grade A only.

REFLECTANCE MEASUREMENTS OF COLOR

Early investigators employing spectrophotometric procedures to analyze colors in foods, employed the technique of extracting the color fractions of foods. Eastmond, Peterson, and Stumpf *(6)* concluded that color differences can be measured more accurately in terms of what an observer actually sees by observing the differences in reflectance characteristics of the entire sample. The authors successfully detected changes in colorimetric properties of various foods by use of a recording spectrophotometer; however, they believed that the data obtained was difficult to interpret, and in addition, the size, complexity, and expense would limit such instruments to use as a research tool.

Actually investigations on the color of the entire sample, rather than on extracted pigments, were carried out as early as 1949 by MacGilliwary *(10)*. In the same year, the determination of color of unclarified juice by use of the Photovolt Reflectometer was accomplished by Worthington, Cain, and Weigand *(20)*. Youkin *(21, 22)* developed a method for measuring objectively the color of raw tomatoes using purees by employing the Hunter Color Difference Meter; and Desrosier, Fawrett and Gaylord *(5)* used this instrument in color grading whole tomatoes. Other reflectance measurement studies on tomato products were performed by Kramer *(9)*, Ciusa *(3)*, Robinson *et al. (14)*, Buck and Sparks *(2)*, Whipple *(18)* and Smith and Huggins *(16)*.

Recognizing that a simple, inexpensive instrument for accurate determination of the color of fruits and vegetables would be of great value to the grower, canner, and inspector, Desrosier *et al. (5)* and Desrosier *(4)* developed the Purdue Color Ratio Meter.

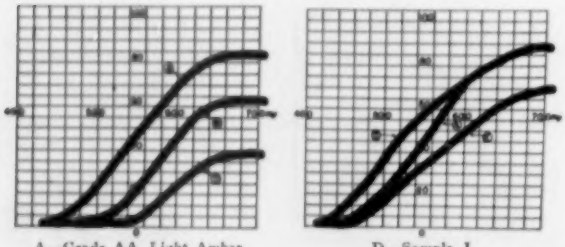
Shah and Worthington *(15)* utilized reflectance measurements to color grade frozen strawberries, and Kraft and Ayres *(8)* studied the discoloration of prepackaged sliced bologna by the same technique. The reflectance of durum products were investigated by Matz and Larsen *(12)* and Morris *et al. (13)* studied the color of peanut butter by special reflectance measurements. Thus, the extreme interest in this form of color analysis is readily apparent.

Tomato products. In the case of the 10 commercial brands of catsup used to study the relationship between the ratio values for the rapid scanning spectrophotometer and the U. S. Department of Agriculture scores for color (Figure 5), the coefficient of correlation was 0.794, which is highly significant (1% level), indicating definite promise for potential use of this instrument. It should be noted that only 10 samples were used in this phase, and to specify the true correlation with more precision, further investigation utilizing a much larger sample should be undertaken.

For grading the color of tomato products, it might appear that a complete scanning spectrophotometer is of little value if one is concerned only with the ratio of percentage of reflectance at 650 mμ to that at 550 mμ. This is probably true, if one is interested only in the score for the product. However, if quality control is of importance and if one is desirous of determining the cause of a sudden drop in score, then the entire spectrum may provide valuable information. The rapidity of operation of this spectrophotometer makes practical the examination of every batch and immediate adjustments necessary in the raw materials or processing conditions, thus precluding the possibility of producing a large quantity of an inferior product.

Once a bottle of catsup has been opened and allowed to come in contact with the air, it rapidly undergoes a change in color. To determine the effect of storage at room temperature on the contents of an opened bottle, several commercial brands of catsup were analyzed spectrophotometrically and then stored at room temperature in a dark room for a period of four months. A significant deviation in the spectral curve indicated the typical change that takes place in catsup upon storage.

[8] Components of the Phoenix Color Comparator Set.



A—Grade AA, Light Amber.
B—Grade A, Medium Amber.
C—Grade B, Dark Amber.
D—Sample I
E—Sample II

Figure 4. Spectral transmission curves of maple sirup glass standards.

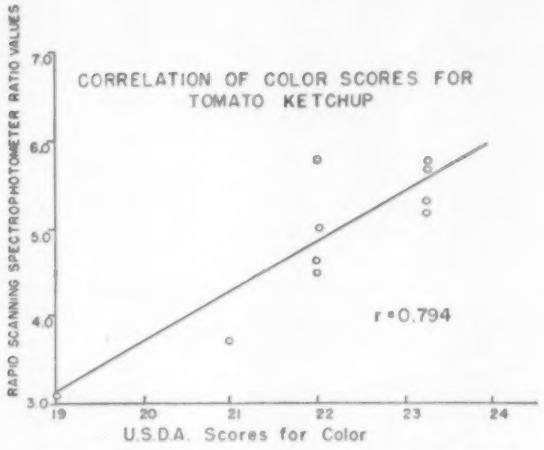


Figure 5. Correlation of color scores for tomato catsup.

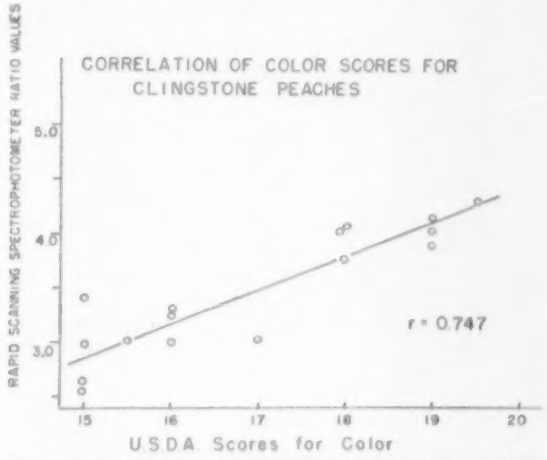


Figure 6. Correlation of color scores for clingstone peaches.

Peaches (canned, clingstone). Color plays an important role in the grading of peaches, although currently there is no purely objective method for determining the color of canned peaches. The Maerz and Paul Color Dictionary system is presently the official method for grading peaches. The amount of green pigment in a peach varies with the degree of ripeness of the peach. In an attempt to evaluate the spectrophotometric curves, the wavelengths corresponding to the beginning and end of the green region (500 and 570 mμ, respectively) were selected as the critical wavelengths for reflectance measurements, and the ratio of the percentages of reflectance at these wavelengths was adopted as the rapid scanning spectrophotometric score.

The correlation between the rapid scanning spectrophotometer ratios and the U. S. Department of Agriculture scores for color of clingstone peaches is shown in Figure 6. The coefficient of correlation of 0.747 is highly significant at the one percent level.

Bologna. The color changes that take place in prepackaged sliced cold cuts such as bologna have become a serious problem with the ever increasing trend toward self-service meat and delicatessen counters. The discoloration of the meat develops rapidly and appears to be accelerated to a great extent by the lighting fixtures used in the display cases. Analysis of the ratio of spectral reflectances of bologna samples at wavelengths of 650 and 570 mμ indicates that after storage for 3 to 4 days the scoring ratio no longer appeared to be a true indication of the actual changes taking place in the color of the samples, because the sample exposed to air darkened rapidly.

The preliminary evaluation of the use of the rapid scanning spectrophotometer in the study of color fading of packaged meat products indicates that the instrument may prove useful in analyzing the color changes in a completely objective manner. It may be used to investigate the effects of various packaging materials, vacuum sealing, lighting conditions, added anti-oxidants and other added ingredients such as spices. From the results of these investigations, valuable information might be obtained to aid in increasing the storage life of prepackaged cold cuts.

SUMMARY

The rapid scanning spectrophotometer studied in this investigation appears to possess the following characteristics:

(a) Complete spectrophotometric curves in the visible range of the spectrum are instantaneously recorded on the face of the instrument, and the readings can be interpreted by simple ratios or other similar indices, rather than by calculation of the tri-stimulus values. Thus, the data can be presented in a convenient numerical form suitable for tabulation and correlation studies.

(b) The rapidity of operation of the instrument permits recording of the transmission or reflectance before any chemical or physical alteration occurs in the sample.

(c) The instrument is capable of recording reflectance measurements as well as transmission measurements; therefore relatively opaque or turbid solutions may be readily analyzed.

(d) The use of an oscilloscope camera attachment, such as the Polaroid Land Camera assembly, makes it possible to procure permanent records of the colors analyzed; these may be used as standards at some future date or as aids in controversies that may arise over color grading.

(e) The rapidity of operation makes it practicable to examine every batch of both raw and processed product, if necessary, and the required adjustments in the production line can be handled on a preventive rather than a "post mortem" basis.

(f) The instrument may prove to be useful in the detection of adulteration and mislabeling of products such as olive oil, provided the spectral curves of samples of known purity are available for comparative purposes.

(g) The instrument appears to have potentialities in studying the effects of various packaging films on the color retention of prepackaged meats.

(h) The rapidity and ease of operation of this instrument should stimulate further interest in undertaking

investigations of the fundamental causes for changes or variations in color in food commodities before, during, and after processing. It would appear, therefore, that this instrument has potential usefulness as a research tool, in addition to its more direct practical applications.

It should be reiterated, however, that further evaluation and correlation with several experienced graders is necessary before conclusive recommendations can be made concerning its use as an objective color grader. The sensitivity of the machine is limited since the scale graduations are large, and the color cannot be readily converted to psycho-physical constants. It appears, however, that the attributes of the rapid scanning spectrophotometer may prove, upon further investigation, to be a useful tool to the food industry.

LITERATURE CITED

1. American Optical Company, Instrument Division. Rapid Scanning Spectrophotometer, Buffalo, New York.
2. Buck, R. E., and Sparks, R. A. Relation of ketchup color to tomato color as determined by the Hunter instrument. *Food Technol.*, **6**, 122-24 (1952).
3. Ciusa, Walter. The determination of color of the tomato conserves with the Beckman Spectrophotometer. *Ind. ital. conserve*, **26**, 37-39 (1951).
4. Desrosier, N. W. Color grading foods with the Purdue Color Ratio Meter. *Food Technol.*, **8**, 204-8 (1954).
5. Desrosier, N. W., Gaylord, F. G., Kellie, W. F., and Ellis, N. K. Meter simplifies color grading of fruits and vegetables. *Food Eng.*, **24**, 92-93 (1952).
6. Eastmond, E. J., Peterson, J. E., and Stumpf, R. R. Observations of color changes in some processed and stored foods. *Food Technol.*, **5**, 121-128 (1951).
7. King, J. Role of color in the laboratory. *Can. Dairy Ice Cream J.*, **33** (5) 42-4 (1954).
8. Kraft, A. A., Ayres, J. C. Color changes in packaged bologna. *Food Technol.*, **8**, 22-6 (1954).
9. Kramer, A. This meter gives better color evaluations. *Food Inds.*, **22**, 1897 (1950).
10. Mac Gillivray, J. H. Color measurement an aid in grading tomatoes. *Canner*, **108**, 14 (1949).
11. Maerz, A., Paul, M. R. *A Dictionary of Color.* 1950. 2nd. ed., McGraw-Hill Book Co., New York, N. Y.
12. Matz, S. A., Larsen, R. A. Evaluating semolina color with photoelectric reflectiometers. *Cereal Chemistry*, **31**, 73-86 (1954).
13. Morris, N. J., Lohmann, M. I., O'Connor, R. T., and Freeman, A. F. Determination of color of peanut butter by a special reflectance method. *Food Technol.*, **7**, 393-97 (1953).
14. Robinson, W. B., *et al.* A study of methods for the measurement of tomato juice color. *Food Technol.*, **6**, 269-74 (1952).
15. Shah, J., Worthington, O. J. Comparison of several methods and instruments for specifying the color of frozen strawberries. (Paper presented at 13th Annual Meeting of Institute of Food Technologists, Boston, Mass., 1953).
16. Smith, T. J., Huggins, R. A. Tomato classification by spectrophotometry. *Electronics*, **25**, 92-94 (1952).
17. U. S. Dept. of Agriculture. Production and Marketing Administration, 1952. U. S. Standards for Grade of Processed Fruits and Vegetables.
18. Whipple, S. R. Grading tomatoes for color. *Canner*, 114, 14-20 (1952).
19. Woodman, A. G. *Food Analysis.* 1941. 4th ed., McGraw-Hill Book Company, New York, N. Y.
20. Worthington, O. J., Cain, R. F., and Weigand, E. H. Determination of color of unclarified juices by reflectiometer. *Food Technol.*, **3**, 274 (1949).
21. Younkin, S. G. Color measurement of tomato purees. *Food Technol.*, **4**, 350-54 (1950).
22. Younkin, S. G. Measurement of small color differences in tomato purees. *J. Optical Soc. Am.*, **40**, 596-99 (1950).

Announcing the 1955 Glycerine Research Awards

FIRST AWARD	**Honor Plaque**	**$1,000**
SECOND AWARD	**Honor Certificate**	**$300**
THIRD AWARD	**Honor Certificate**	**$200**

The purpose of this group of awards, established in 1952 by the Glycerine Producers' Association, is to recognize and encourage research leading to new and improved applications of glycerine or glycerine derivatives to products or processes. The work may concern itself with the chemical, physical or physiological properties of glycerine, or with properties of glycerine-containing or glycerine-derived materials. It may deal with applications which of themselves are currently or potentially of value to industry or the general public, or it may deal with scientific principles or procedures likely to stimulate future application. Originality in extending the application of glycerine into new fields of usefulness will receive special consideration for awards.

BASIS OF ENTRY

These awards are open to any individual in the United States and Canada engaged in research, whether employed in industry or affiliated with a governmental or educational institution (faculty or college student) except those connected with member companies of the Glycerine Division, Association of American Soap & Glycerine Producers, Inc., or laboratories which they employ. (Joint entries by research teams or associates of two or three individuals are also eligible.)

PERIOD OF AWARD

First consideration for the 1955 Award will be given to work which has come to a successful conclusion or clear-cut point of accomplishment during the current year, regardless of the date at which the work was initiated. Work carried on in previous years, but the significance of which has been confirmed by commercial application in 1955, will be eligible.

JUDGES

Selection of award winners will be made by a committee of three judges of outstanding reputation and appropriate scientific background, having no connection with the Association or its members.

DATE FOR NOMINATIONS

All nominations for the 1955 awards must be received by *November 1, 1955.*

METHOD OF NOMINATION

Only nominations made on the official entry blank will be eligible for awards. For a copy of this official entry blank, write to: *Awards Committee, Glycerine Producers' Association, 295 Madison Avenue, New York 17, N. Y.*

DIRECTORY

The Institute of Food Technologists

President

LAVERNE E. CLIFCORN
American Can Company
Research Center
Barrington, Illinois

President-Elect

GEORGE F. GARNATZ
The Kroger Food Foundation
1212 State Avenue
Cincinnati 4, Ohio

Executive Secretary

CHARLES S. LAWRENCE
176 W. Adams Street
Chicago 3, Illinois

Assistant Executive Secretary

MARIAN A. GILCHRIST
176 W. Adams Street
Chicago 3, Illinois

Treasurer

AKSEL G. OLSEN
General Foods Corporation
1125 Hudson Street
Hoboken, New Jersey

Assistant Treasurer

ARTHUR N. PRATER
Gentry Division
Consolidated Foods Corp.
837 N. Spring Street
Los Angeles 12, California

Executive Committee of the Council

L. E. Clifcorn, P. K. Bates, G. F. Garnatz, A. G. Olsen, H. D. Brown, J. A. Dunn, A. A. Schaal, R. B. Wakefield, M. I. Wegner.

Councilors-at-Large

Terms Expire 1956: B. S. Clark, J. A. Dunn, C. N. Frey, L. A. Hall, H. S. Olcott.

Terms Expire 1957: G. M. Dack, S. L. Galvin, E. M. Mrak, C. S. Pederson, R. B. Wakefield.

REGIONAL SECTION CHAIRMEN, SECRETARIES AND COUNCILORS

CHICAGO, No. 1: Chairman, J. M. Jackson. Secretary, Bernard J. McKernan, Continental Can Co., Res. & Dev., 4645 W. Grand Ave., Chicago 39, Ill. Councilors, G. E. Brissey, M. Ives, J. M. Jackson, R. H. Maher, H. H. Mottern, G. T. Peterson, R. G. Tischer.

NORTHERN CALIFORNIA, No. 2: Chairman, G. Mackinney. Secretary, Frank C. Lamb, National Canners Assn., 1950 Sixth St., Berkeley 2, Calif. Councilors, H. T. Griswold, E. E. Jacobs, E. M. Mrak, A. C. Richardson.

NORTHEAST, No. 3: Chairman, E. E. Lockhart. Secretary, Ernest R. Barron, First National Stores, 5 Middlesex Ave., Somerville 45, Mass. Councilors, S. A. Goldblith, L. B. Sjostrom.

SOUTHERN CALIFORNIA, No. 4: Chairman, J. R. Lindquist. Secretary, Gordon L. Merchant, Merck & Company, Inc., 1855 Industrial St., Los Angeles 21, Calif. Councilors, W. E. Baier, M. E. Powell, M. S. Dunn.

ST. LOUIS, No. 5: Chairman, P. Logue. Secretary, Albert C. Roland, The Roland Flour Co., 3517 Gratiot St., St. Louis 3, Mo. Councilor, M. I. Wegner.

NEW YORK, No. 6: Chairman, F. C. Baselt. Secretary, Eleanor M. Crozier, Minute Maid Corp., 488 Madison Ave., New York 22, N. Y. Corres. Secretary, W. A. Maclinn, N. J. Agri. Exp. Sta., New Brunswick, N. J. Councilors: C. N. Frey, R. F. Light, O. Skovholt, S. L. Galvin, A. A. Schaal.

FLORIDA, No. 7: Chairman, R. Patrick. Secretary, W. Clifford Scott, U. S. Citrus Products Station, Winter Haven, Fla. Councilor, R. W. Kilburn.

WESTERN NEW YORK, No. 8: Chairman, A. A. Gendreau. Secretary, Jean I. Simpson, College of Home Economics, Syracuse Univ., Syracuse 10, N. Y. Councilor, W. S. Conway, Jr.

GREAT LAKES, No. 9: Chairman, W. L. Thompson. Secretary, William F. Robertson, Dept. of Horticulture, Michigan State College, East Lansing, Mich. Councilor, L. J. Minor.

PHILADELPHIA, No. 10: Chairman, L. W. Mahle. Secretary, Norman Kramer, U. S. Food & Drug Adm., New Customhouse, Second & Chestnut St., Philadelphia 6, Pa. Councilor, J. P. Crimmins.

MARYLAND, No. 11: Chairman, L. V. Strasburger. Secretary, William A. Feild, 120 Melvin Avenue, Baltimore 28, Md. Councilors, H. W. Kuhl, H. Reynolds.

PUGET SOUND, No. 12: Chairman, J. A. Ardussi. Secretary, Louis G. Germain, American Can Company, Seattle, Wash. Councilor, G. M. Danielson.

AMES, No. 13: Chairman, E. W. Bird. Secretary, Frances Carlin, Foods & Nutrition Dept., Iowa State College, Ames, Iowa. Councilor, W. H. Montgomery.

MOHAWK VALLEY, No. 14: Chairman, T. F. Irmiter. Secretary, Henry W. Ballou, Beech-Nut Packing Co., Canajoharie, N. Y. Councilor, M. Glickstein.

OHIO VALLEY, No. 15: Chairman, F. E. Deatherage. Secretary, Beatrice Finkelstein, 202 E. Bruce Ave., Dayton 5, Ohio. Councilor, H. D. Brown.

OREGON, No. 16: Chairman, E. W. Harvey. Secretary, Curtis J. Wilder, Food Technology Dept., Oregon State College, Corvallis, Ore. Councilor, C. L. Beardsley.

DIXIE, No. 17: Chairman, J. G. Woodroof. Secretary, Carroll F. Neff, 193 Princeton Way, N. E., Atlanta 6, Georgia. Councilor, J. O. Mundt.

TEXAS, No. 18: Chairman, J. H. Gast. Secretary, Kenneth K. Keneaster, Converted Rice, Inc., P. O. Box 1752, Houston 1, Texas. Councilor, B. L. Golub.

AUSTRALIA NORTHERN No. 19: Chairman, V. M. Lewis. Secretary, Allan T. Roche, W. H. Brookhouse, Pty. Ltd., 92-100 Derby St., Auburn, N. S. W., Australia. Councilor, H. Govers.

INDIANA, No. 20: Chairman, V. R. Rupp. Secretary, Verna McCallum, 941 N. Meridian, Indianapolis 6, Ind. Councilor, N. W. Desrosier.

PITTSBURGH, No. 21: Chairman, C. J. Steinicke. Secretary, John L. Secrist, H. J. Heinz Co., Food Research Dept., Pittsburgh 30, Pa. Councilor, H. L. Lang.

BRITISH COLUMBIA, No. 22: Chairman, D. H. Dougans. Secretary, William E. Pearson, Lucky Lager Brewing Co., 210 Brunette St., New Westminster, B. C., Canada. Councilor, I. F. Greenwood.

AUSTRALIA SOUTHERN, No. 23: Chairman, J. E. Rice. Secretary, Kevin B. Smith, Southern Can Co. Pty. Ltd., 240 Geelong Road, West Footscray, W-11, Victoria, Australia. Councilor, M. K. Paxton.

AK-SAR-BEN, No. 24: Chairman, G. C. Kolb, Jr. Secretary, Harriet L. Paige, C. A. Swanson & Sons, 1202 Douglas, Omaha 8, Nebr. Councilor, I. L. Ressler.

MEMBERSHIP

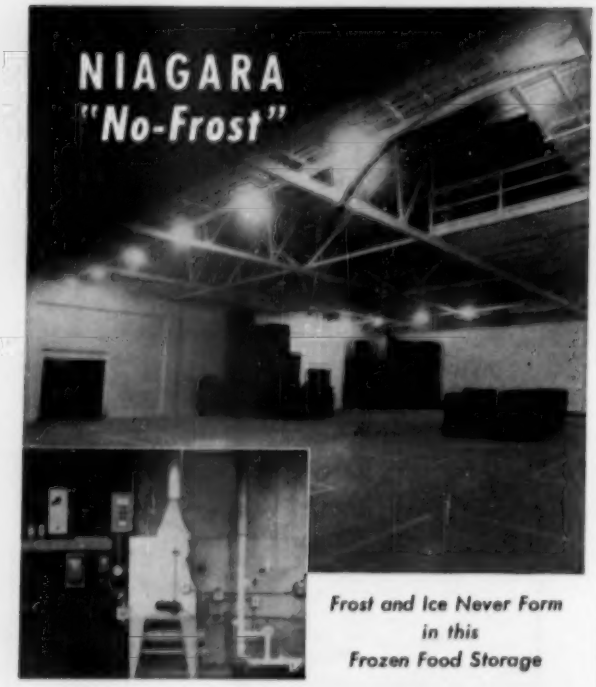
Write to nearest regional secretary, if within an area covered by a regional section, or to the Executive Secretary of the Institute for an application form and information regarding qualifications and classifications.

the essence of good taste . . .
maplearome
IMITATION MAPLE FLAVOR BASE
. . . a product which through the years has been the standard, the perfect imitation Maple Flavor Base . . . Check its amazing consistency and you can appreciate it has never changed from its premium quality . . . Most economical for manufacturing purposes . . .
MAPLEAROME
Florasynth LABORATORIES, INC.
CHICAGO 6 • NEW YORK 62 • LOS ANGELES 21
Cincinnati 2 • Detroit • Dallas • Memphis • New Orleans 12
St. Louis 2 • San Francisco • San Bernardino
FLORASYNTH LABS. (Canada Ltd.)
• Montreal • Toronto • Vancouver • Winnipeg •
PRODUCTOS Y LABORATORIOS FLORASYNTH, S. A.
MEXICO 11, D. F.

AHHHHHHHHhhhh...
it must be
Florasynth's
WORCESTERSHIRE
SAUCE BASE
AND
BARBECUE
SAUCE BASE
. . . you're cookin'. . . Nothing else matches it . . . Only Florasynth's bases can stir your appetite so easily . . . and yet so economically . . . impart to your sauce an aroma and taste utterly irresistible . . .
TRY A SAMPLE . . .
Florasynth
LABORATORIES, INC.

EXECUTIVE OFFICES **900 VAN NEST AVE.**, (BOX 12), **NEW YORK 62, N. Y.**
CHICAGO 6 :: LOS ANGELES 21

Created by Nature . . .
. . . Retaining the inherent goodness and richness of the natural product, these superb compounds of natural oils are evidence of Florasynth's matchless skill of research and distillation.
Duplicated by Florasynth
CITROSYNTH LEMON OIL
CITROSYNTH ORANGE OIL
CITROSYNTH LIME OIL



Frost and Ice Never Form in this Frozen Food Storage

SAVE TROUBLE AND EXPENSE EVERY DAY IN PRE- COOLING, FREEZING AND STORAGE; PROTECT FRESH OR FROZEN FOOD QUALITY

The Niagara "No-Frost" Method gives you always the full capacity you paid for in your refrigeration, NEVER, not even partially, interrupted for defrosting. You can handle large "live" loads easily. The controls are simple and always give you accurately the temperature and humidity you want. Temperatures never rise to interrupt the "pull-down". You are free of troubles; your rooms stay clean and sweet with easier maintenance and less labor. You save power; your compressors run at higher suction pressures. For every refrigerated room for temperatures below 32° F. this method gives you better product quality at lower operating costs. Many of the finest installations in the industry, both large and small, prove the benefits of the Niagara No-Frost Method.

Write for the No-Frost story and data on its application to your problem. Ask for Bulletin No. 105.

NIAGARA BLOWER COMPANY
DEPT. F.T., 405 LEXINGTON AVE., NEW YORK 17, N. Y.

OVER 15 YEARS OF SUCCESSFUL EXPERIENCE PROVES THE VALUE OF NIAGARA NO-FROST

FOOD INDUSTRY TOPICS

(Continued from page 22)

A new type, manually operated hydraulic closing device for filter presses has been developed by D. R. Sperry and Co., Batavia, Ill., filtration engineers. Called the "Handraulic," the new closing device requires no additional support or foundation, and therefore can be added to existing filter presses in the field without alterations, re-boring, or removal of any plates. The "Handraulic" provides a high power-to-work ratio, increasing the efficiency of filter press closings and openings and minimizing the operator's job.

Rhodia, Inc., 230 Park Ave., New York 17, N. Y., announces addition of "Alamask" CPM-55 and "Alamask" CPM-55-X to its line of industrial chemical reodorants for industry. They have been developed primarily for use in the rendering, fat processing, fish, fertilizer, and allied industries. Designed for addition to processing, the products offer improved abatement of malodorous gases traceable to amines, proteins, and aldehydes. They are stronger than previous "Alamask" reodorants, thus offering lower cost of application.

The number of products considered "hard-to-package" has been greatly reduced with introduction of an **improved lining material for steel shipping containers,** according to announcement by Steel Shipping Container Institute, Inc. Designated "Synthetasine 200," the material is a combination of thermosetting phenolic and epoxy resins developed at Battelle Memorial Institute, Columbus, O., as part of a continuous research program on protective coatings sponsored by Steel Shipping Container Institute. While not a "universal protective coating," the product reportedly protects many products which formerly could not be packaged successfully in lined steel containers. It is expected to be excellent in general for alkali, detergents, chlorinated solvents, fatty acid, emulsions, aromatic and aliphatic hydrocarbons, and food products. The coating is being produced by licensees of Synthetasine Protective Coatings, Inc., 600 Fifth Ave., New York 20, N. Y.

The VirTis Extracto-Matic, **an automatic separatory funnel,** allows up to eight extractions to be performed at one time. The rocker arm swings up and down through a 90° arc at the rate of 20 oscillations per minute, assuring the complete agitation and intimate contact necessary to full extraction. The Pyrex separatory funnels are designed to eliminate need for a stopper while rocker arm is in motion. Hence, there is no possibility of pressure build-up. The fluid openings always remain above the solution level to prevent leakage or spilling. Write E. Machlett & Son, 220 E. 23rd St., New York 10, N. Y.

The heating element is actually die cast into the sole of the new Lewsyth "Flaming Feather" hand

(Continued on page 30)

SOLUBLIZED SPICE FLAVORS...

Symphony IN SEASONINGS!

Among spice flavors, Griffith's *Solublized* Seasonings have the rich, full-flavor quality of the Symphony. The mellow, balanced harmony that can win more patronage for your product!

Griffith—*both composer and master artist*—renders a customer's "*flavor score*" with such fidelity, even critics applaud. Blending the woodwinds, violins, horns and 'cellos *of the spice realm* into a more harmonious sensation of flavor tones so pleasing to your particular patronage.

Connoisseurs of flavors, practiced in the science of spice blending for over 30 years—Griffith artistry will give your product a new high in taste appeal. Try Pepperoyal, or a special blend of *Solublized* Seasonings—now.

The

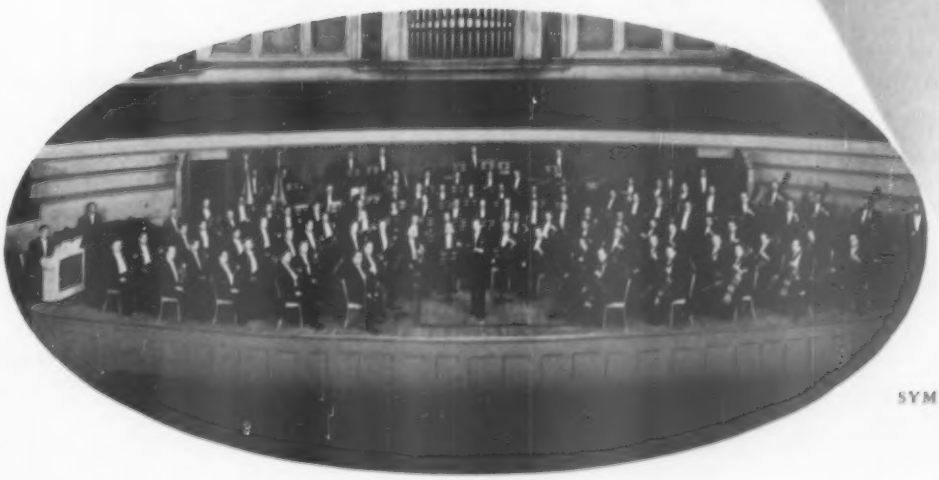
GRIFFITH

LABORATORIES, Inc.

In Canada—The Griffith Laboratories, Ltd.

CHICAGO 9, 1415 W. 37th St. • NEWARK 5, 37 Empire St.

LOS ANGELES 58, 4900 Gifford Ave. • TORONTO 2, 118 George St.



CHICAGO SYMPHONY ORCHESTRA

FOOD INDUSTRY TOPICS

(Continued from page 28)

sealing iron for plastic film wraps, allowing the unit to seal pliofilm only 20 seconds and cellophane only 45 seconds after plug-in. Other benefits are stated to be prevention of element "burn-out" because of the iron's instant dispersion of heat, and quick heat recovery after contact with cold meats, etc., permitting more work to be done with one unit. Weighing 14 ounces, and providing a heat selection between 200° and 600° F., the Model A Flaming Feather is U. I. approved. Manufactured in the U. S. by Hawkins Machine Co., Cuyahoga Falls, O., it is available only through Lewsyth Packaging Systems and Equipment, 11100K4 Cumpston St., Unit No. 18, North Hollywood, Calif.

◆ ◆ ◆

A new 40 h.p. steam generator only 83¼" long by 57¾" high by 36½" wide is announced by Cyclotherm Division, National-U. S. Radiator Corp., Oswego 6, N. Y. The new, electronically controlled unit incorporates all latest design improvements and safety devices to protect the boiler, insure trouble-free operation, and maintain an efficiency of 80% or better. Output is 1,380 pounds of steam per hour and 1,340,000 btu per hour. Standard design pressures are available from 15 to 200 psi. The boiler burns oil, gas, or a combination of oil and gas.

A mechanically bonded laminate reinforcing material of Du Pont synthetic fibers is being introduced for the reinforced plastics industry. The material, in needled-batt structures of nylon, "Orlon" acrylic fiber, or "Dacron" polyester fiber, was developed by two manufacturers in cooperation with the Du Pont Textile Fibers Department. It differs from most other non-woven reinforcing media in that it is constructed by bonding the fibers mechanically, rather than chemically or thermally. Thus, there is little or no degradation before use, even when stored for long periods. Outstanding dielectric properties make the material especially suited for critical electrical and high-frequency applications. Other end-use products for which the manufacturers recommend the synthetic-fiber batts include laminates for chemical-resistant tanks, food and dairy industry equipment, and consumer goods requiring smooth finish and surface. Available in any of the three fibers and in a variety of weights and widths adaptable for either overlay or total reinforcement, it is manufactured under the trade-name of "Mofelt" by the Charles Lachman Co., Inc., subsidiary of the Mohawk Carpet Mills, Inc., Franklin and Grant Sts., Phoenixville, Pa., and under the trade-name of "Troytuf" by the Troy Blanket Mills, 200 Madison Ave., New York 16, N. Y.

(Continued on page 32)

ACCESSORY NUTRIENT FACTORS

For the luxuriant growth of all lactic acid bacteria yeasts and molds assured by the use of

EXCHANGE BRAND ORANGE SERUM AGAR #77

(Dehydrated) a Complete Culture Medium

FORMULA — *Ingredients—when rehydrated on basis of 45 grams per liter of medium.*	
Orange juice serum solids	12.6g*
Agar (dry basis)	15g
Peptone	10g
Yeast hydrolysate	3g
Reducing sugars, total	8g
Sucrose, total	6g
Cysteine hydrochloride	0.001g

Buffered with 0.2 to 0.6g K_2HPO_4 to provide pH 5.5 ±0.05 after sterilization.

**Equivalent to 100 ml 12° Brix orange juice serum.*

STANDARDIZED for uniformity and stability.

POTENTIAL APPLICATION—Orange Serum Agar as an all-purpose medium has a wide application to the bacteriologist and microbiologist in the milk, fruit pickling, food, bottling and fermentation industries.

Available in 1 lb. bottles through your laboratory supply house.

Sunkist Growers

PRODUCTS DEPARTMENT

Exchange

PHARMACEUTICAL SALES · ONTARIO, CALIFORNIA

WHEN ACCURACY MEANS DOLLARS-AND-CENTS SAVINGS

...another highest-accuracy control instrument from the most complete line serving industry

DEPENDABLE QUALITY CONTROL • Index accuracy to .00003 . . . assures identification of samples whose indexes are very close together. Tests transparent or opaque samples, liquid or solid, by transmitted or reflected light. Three readily interchangeable prism assemblies cover range of 1.20 to 1.70. Wear-compensated parts assure year-after-year accuracy. Special test prism available for instrument check, certified by U.S. Bureau of Standards.

FAST, EASY READINGS • Built-on sodium vapor illuminator provides bright, sharp dividing line. Mercury light source also available for high accuracy dispersion readings. Long-focus telescope system makes it easy to match dividing line with crosshairs. Illuminated vernier and magnifying eyepiece provide quick reading of widely graduated scale. Inclination joint adjusts instrument to individual reading comfort.

NOW! PRECISE TEMPERATURE CONTROL INCREASES TEST ACCURACY • B&L Total Immersion Thermometer, ASTM-approved, reads accurately to ±.1°. Mounts in circulating system of B&L Precision Refractometer, protected from drafts and breakage. Magnifying eyepiece, built-in illuminator. (Optional)

WRITE TODAY FOR DATA AND DEMONSTRATION

Informative Catalog D-202, and obligation-free demonstration, yours on request. Write to Bausch & Lomb Optical Co., 69045 St. Paul St., Rochester 2, New York.

BAUSCH & LOMB

SINCE 1853

America's only complete optical source . . . from glass to finished product.

FOOD INDUSTRY TOPICS

(Continued from page 30)

Specially designed for small, important, often difficult work, the **new Model LTX Power Bench Type Punch Press,** manufactured by Alva Allen Industries, 1001-1015 N. 3rd St., Clinton, Mo., is ideal for slotting, cutting, pinking, scoring, marking, embossing, perforating, creasing, punching material such as leather, plastics, textiles, paper, fibre, metals, etc. It will mass produce, with a capacity up to 250 operations per minute of continuous operation. Requires only ⅓ h.p. motor and has direct V-Belt drive. Weight is 110 pounds, stroke one inch.

A new line of low cost, clear, rigid styrene plastic half-gallon boxes and lids is announced by Wilpet Tool & Mfg. Co., Kearny, N. J. The new half-gallon pack is available in clear or colored boxes, with plain, printed, or labeled clear or colored lids. It serves as a multiple re-use item for consumers as a refrigerator box, sewing box, small storage box, etc.

Newest model added to the Rietz Disintegrator line incorporates major changes in design and operation to widen application to the general field of continuous grinding, mixing, and size reduction. Side-mounted, belt-driven motor gives the Disintegrator variable speed operations from 1200 RPM to a maximum of 5000 RPM, utilizing a 3600 RPM motor of from 30 hp up to 125 hp, with 2 sets of belts and four pulleys. This combination allows six different speed ranges, with a changing time of less than 30 minutes. First of the new models is the RD-18-H32, an 18″ rotor diameter unit. Write Rietz Mfg. Co., Santa Rosa, Calif., or its District Offices at 1969 Bartle Ave., Scotch Plains, N. J., 217 W. Main St., St. Charles, Ill., and 725 Forsyth Bldg., Atlanta, Ga.

A new line of **electrically operated "packaged" steam generators** has been announced by Pantex Mfg. Corp., 407 Roosevelt Ave., Pawtucket, R. I. Called the Pantex Speedylectric, these self-contained units operate on the electrode principle of generating steam electrically, and have been given full U. L. listing in sizes from 1½ to 15 Bhp. Applications have been found wherever precise control of high pressure steam temperature is desired, or in places where fuel-fired boilers create an explosion, fire, or fume hazard, or as supplementary steam sources for areas remotely located from central boilers. Efficiency is reported to be 98½%—power factor 100%.

A new durable laboratory balance with features that simplify and speed up weighing operations is announced by The Torsion Balance Co., Clifton, N. J. Features of the new Model LA-3 include torsion bands made of Elgiloy, a stronger, corrosion-resistant alloy; a single beam with vernier, permitting accurate weighings from .01 gm to 10 gm without use of loose weights; stainless steel calibrated beam assembly positioned so as to minimize vibration effects; an oil damper to reduce balance oscillation. Capacity of the balance is 200 gm, and the sensitivity reciprocal .02 gm. The balance is equipped with a 5″ removable stainless steel weighing pan. Shipping weight is 11 pounds.

(Continued on page 34)

Margarine makers need '999'

So do makers and processors of beer . . . candy . . . canned foods . . . cereals . . . malted milk . . . mayonnaise . . . meats . . . olives . . . sauerkraut . . . seasonings . . .

Morton '999' Salt
for better flavor and quality

Morton '999' Salt insures uniform flavor and quality in processed foods for two reasons:

1. Morton '999' is *guaranteed* always to contain more than 99.9% pure sodium chloride. The remaining 0.1% (or less) is a neutral inert sodium salt—and never bitter calcium or magnesium compounds.

2. Morton '999' Salt is produced by vacuum pan evaporation to assure you a salt that is clean, free-flowing... evenly soluble. '999' Salt is particularly low in objectionable trace metals.

For more information about Morton '999' Salt—and about Morton service and technical help—write this week to:

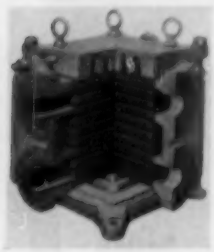
MORTON SALT COMPANY

Industrial Division, Department T9-9
120 South La Salle Street, Chicago 3, Illinois

FOOD INDUSTRY TOPICS

(Continued from page 32)

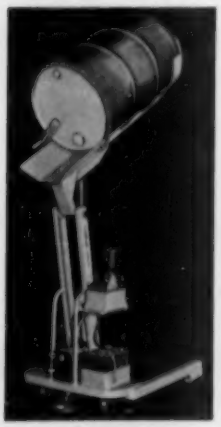
A new Impervite Cubical Exchanger, consisting of a specially formed impervious graphite cube housed in heavy cast iron headers, is available from Falls Industries, Inc., 31883 Aurora Rd., Solon, O. The unit is extremely compact—a 15″ cube providing 50 square feet of effective heat transfer surface, and requiring only ⅛ the floor area necessary to house a tube and shell type exchanger with equal transfer surface. The Cubical Exchanger also can be fabricated from Graph-I-Tite, a new carbon-impregnated impervious graphite capable of withstanding operating temperatures to 5700° F., and featuring an even greater scope of chemical resistance than Impervite. Impervite Cubical Exchangers are being produced in 9″ and 15″ cube sizes, both of which can be slotted to double the transfer surface. Counter-current flow is provided in all multipass cubical exchangers up to 16-pass. Where desired, all headers can be lined to permit handling 2 corrosives.



◆ ◆ ◆

A new line of Type C materials handling valves, designed for efficient flow control in pneumatic transport of fine solid materials, is announced by The Allen-Sherman-Hoff Co., 259 E. Lancaster Ave., Wynnewood, Pa. The valves offer advantages of self-feeding, non-plugging operation with positive shut-off, maximum carrying capacity, minimum frictional wear, and ease of maintenance in handling such materials as boiler fly ash and other industrial dusts. Intended for installation in vacuum transport piping systems, A-S-H Type C valves are available with either air-slectric, remote, or manual controls.

◆ ◆ ◆



The Tubar Dumper, a new, low-cost hydraulic unit, designed to empty or transfer the contents of one container into another, is especially designed to meet mounting demand for a unit of this type in paint, chemical, petroleum, food, drug industries, and in various machine shop operations. Available with either manual or electric lifts, it has a capacity of 750 pounds. The manual model (starting at $285) is equipped with a double-acting, variable stroke hydraulic pump. The electric model (starting at $585) operates on any standard 6-volt automotive battery, and is furnished complete with charger, but less battery. Both models feature a positive floor lock. Forks for pallet and skid dumping are available as accessories. Write Uhrden, Inc., P. O. Box 51, Dennison, O.

An entire line of liquid coolers designed to handle various liquids as part of any specialized manufacturing process, is offered by The Vic Mfg. Co., 1313 Hawthorne Ave., Minneapolis 3, Minn. Included are heat exchangers that cool liquids through use of water; water chillers, which chill water by refrigeration and then use this chilled water over and over; and refrigerating coolers, which cool the liquid requiring treatment by direct refrigeration methods. The firm also offers its easily installed Water Saver and Temperature Regulating Valve, applicable to use on degreasers, water-cooled air compressors, plastic moulding machines, and other processing equipment. Price is $30 complete.

. . . *the literary corner*

"Nowhere in the field of promotion is so much time, effort, and money wasted as on press releases . . . The average business publication editor uses only 20% of the releases he receives and complains bitterly about the vast number of publicity hand-outs he gets daily that aren't of the slightest value to his publication. On top of this, editors consider only 27% of the releases they receive 'good,' and hang a 'poor' label on 52%." These are the cogent opening statements from an attractively printed 4-page reprint published by Advertising Requirements, 200 E. Illinois St., Chicago 11, Ill. The reprint sets forth an ample number of "Do's" and "Don'ts" for news releases and photo releases. Anyone concerned with preparation of news releases should find the information invaluable. Single copies are available at 25c each, 10 or more at 15c each, 50 or more at 12½c each, and 100 or more at 10c each. Address Reprint Editor at the above address, enclosing payment for orders totaling less than $1.

◆ ◆ ◆

A new bulletin and a data sheet are available from Minneapolis-Honeywell Regulator Co., Industrial Division, Wayne and Windrim Aves., Philadelphia 44, Pa. Twenty-four page Bulletin 1130, "Program Control of Process Variables," describes methods and advantages of employing automatic, time-conditions control for many industrial processes and tests. A convenient "selection chart" aids in choosing the right instrument for any program control application. Data Sheet No. 10.9-1a describes thickness or weight control of pages, rubber, foil, coatings, and other moving sheet materials. Thickness or weight per unit are continuously measured and controlled by Tracerlab Beta Gages equipped with Brown ElectroniK instruments. Applications, principles, features, and instrumentation are given.

◆ ◆ ◆

The always interesting *Chemmuniqué,* July-August issue, published by Atlas Powder Company, Wilmington 99, Del., in a short article entitled "Protecting Your Products Against Mold Growth," points up the strange fact that when a small amount of polyol (such as sorbitol) or emulsifier is used, molds, yeasts, or bacteria are more likely to grow than when a large amount of the polyol or emulsifier is present. Recent research, it states, indicates that sorbic (2,4 hexadienoic) acid is the best preservative for cosmetics or pharmaceuticals containing either sorbitol or emulsi-

fiers. It is recommended at a level of about 0.2% of the total ingredient weight. In addition, as a preservative for sorbitol-containing formulas, or for dilute sorbitol solutions, a mixture of methyl and propyl parabens, U.S.P., is recommended, in a concentration of 0.12–0.18% methyl and 0.02–0.05% propyl, based on total ingredient weight. However, as the publication says, "Atlas doesn't make these preservatives. And, *Chemmuniqué* has not yet gotten around to handling advertising for other companies, so you'll have to look up your suppliers for these things for yourself."

A 4-page bulletin describing their new automatic infrared spectrophotometer is available from Beckman Instruments, Inc., Fullerton, Calif. The Model IR-2A described is a high-performance, low-cost instrument suited to both research and quantitative analysis. The bulletin gives full specifications and exact reproductions of the transmittance type curves produced by the IR-2A. Included is the spectrum of polystyrene, an accepted test for infrared instruments. Request Bulletin 410. The firm also announces Bulletin 416, describing a new Beckman leak detector utilizing the radio-frequency mass-spectrometer principle. Incorporating both audible and visible warning, the instrument measures leak rates of one part in 700,000. Applications are found wherever high-vacuum systems, pressure systems, or hermetic seals are used.

Sindar Corp., 330 W. 42nd St., New York 36, N. Y., announces listing of hexachlorophene –G–11[R], and hexachlorophene liquid soap in the 15th revision of the Pharmacopoeia of the United States. The latter is stated to be the only antiseptic soap recognized by the U.S.P.

A macroscope which provides an erect, unreversed image useful in production line operations, inspection, and quality control is announced by Bausch & Lomb Optical Co., 635 St. Paul St., Rochester, N. Y. Magnifications of 10X, 20X, or 40X are available, suitable for a wide variety of industrial applications. Price of the macroscope alone is $70. The tripod stand sells for $13, and the microscope-type stand sells for $14. Literature D-1052 describes the macroscope and its uses.

Just off the press is the colorful new Flavor Catalog and Price List issued by Fritzsche Brothers, Inc., 76 Ninth Ave., New York 11, N. Y. Among the many flavor groups featured are the Spicing Compounds for catsups, mayonnaise, meat products, pickles, etc., the Natural Fruit Flavors and concentrated extracts, Citrus Concentrates, Flavors for confections, soft drinks, bottlers' extracts, dessert powders, cordials and liqueurs, along with hundreds of other miscellaneous flavoring specialties. Address the firm's Flavor Division.

"Chemical Market Abstracts," a monthly literature research service covering market news and statistics for the chemical industry, has announced publication of its first Annual Index, covering the year 1954. The volume contains over 22,000 separate entries, classified under the following major subject headings: company names, foreign countries, trade-marks, and in-

the greatest advance in meat seasoning

Scientifically manufactured MAGNA SPICE CONCENTROLS have modernized the seasoning of meats by making available the true flavor components of herbs and spices in the most concentrated form known to Science . . . yet easily processed in your own plant. All the flavor is released immediately. Each batch of your product is uniformly and identically seasoned.

- Out perform crude herbs and spices.
- Easy to measure — easy to mix.
- No spoilage.
- Cut seasoning costs up to 40%.

Write for the new MM&R booklet — "The Greatest Advance in Meat Seasoning."

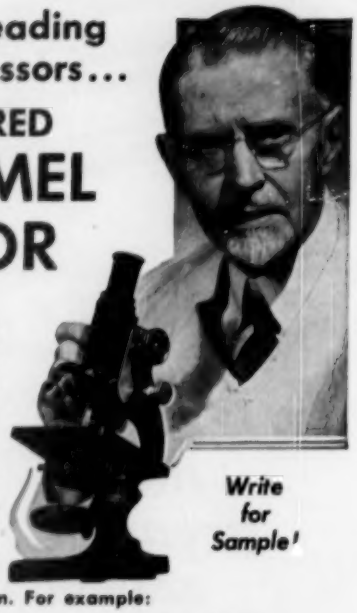
MAGNUS, MABEE & REYNARD, INC.

Since 1895 • One of the World's Greatest Suppliers of Essential Oils and Flavors

16 DESBROSSES STREET, NEW YORK 13, N. Y., U.S.A.
221 NORTH LaSALLE STREET, CHICAGO 1, ILL., U.S.A.

Used by Leading Food Processors...

POWDERED CARAMEL COLOR



A dehydrated food color, made entirely from dextrose sugar by cooking under controlled conditions.

It has particular use in dry food products where the use calls for a natural color ranging from a light to a very dark brown. For example:

Write for Sample!

Powdered Desserts *Dehydrated Soups*
Dry Cake Mixes *Bouillon Powders*
Powdered Coffee & other beverages
Powdered Gravy Seasonings

S. TWITCHELL CO.
CRESTMONT & HADDON AVES. • CAMDEN 4, N.J.

FOOD INDUSTRY TOPICS

dustrial uses of chemicals. Further listings offer references to domestic and foreign patents in the chemical field, and to unit-consumption factors as reported in the trade press. Publication of the Index reportedly marks the first time that a complete guide to the events of an entire year, specifically of interest to the chemical industry, has been made generally available. "Chemical Market Abstracts" is published by Foster D. Snell, Inc., 29 W. 15th St., New York 11, N. Y.

◆ ◆ ◆

Four new items of laboratory equipment added to their extensive line by Labline, Inc., 217-221 N. Desplaines St., Chicago 6, Ill., are described in technical literature available. Bulletin 23700 describes 3 electrically heated, stainless steel hot air sterilizers, marketed under the trade name of "Sterl-Cabs." The sterilizers provide thermostatically controlled temperature up to 270° C., and feature a G.E. motor blower that directs air uniformly through the entire interior of the chamber at rates from 75 to 250 feet per minute. Ranging in size from 19" by 19" by 19" to 37" by 25" by 19", they are suitable for the laboratory or central supply room, and also can be used for routine laboratory evaporation and drying tests in all types of industrial laboratories. Bulletin 3900 covers a new Revolving Shelf Oven for use with ASTM Test D-6 for "Determination of Loss on Heat of Oil and Asphaltic Compounds." Operating at 163° F., the oven features aluminum interiors, thermowall construction, and has no inside exposed heaters, thus reducing fire and explosion hazards.

Revolving Shelf Oven

◆ ◆ ◆

For Izaak Waltons among the readership, the July issue of *D & O News*, published by Dodge & Olcott, Inc., 180 Varick St., New York 14, N. Y., presents an interesting "Fish Story." It seems that fish lures are among the many unusual odors the D&O Laboratories have been asked to supply.

◆ ◆ ◆

An article on poison-imprinted safety cups is featured in the June issue of *Orkin Talkin*, published by Orkin Exterminating Co., P. O. Box 647, Atlanta, Ga. The pest-control firm suggested development of the item some years ago in connection with use of a chemical known as 1080. Since then, the imprinted cups have been adopted as standard items by the U. S. Public Health Service and by other exterminators, for the dispensing of 1080 and other rodent poisons.

◆ ◆ ◆

Of interest to process engineers in the food, pharmaceutical, chemical, and plastic industries is the Acoustica Model DR-400 Ultrasonic Vibrator for agitation, emulsification, dyeing, scouring, and bleaching, described in Bulletin DR-400, published by Acoustica Associates, Inc., Shore Rd., Glenwood Landing, L. I., N. Y. An explanation of the one-knob control unit's above-audibility sound wave principle of operation is presented. Also included are cost-saving applications in specific industries.

◆ ◆ ◆

The United States Testing Company, 1415 Park Ave., Hoboken, N. J., announces publication of a booklet entitled "Selected Scientific and Engineering Tables and Data." Issued in commemoration of the firm's 75th anniversary, the 112-page paper-bound volume contains selected Chemical & Physical, Engineering, Plastics, Bacteriological, Leather, Psychometric and Textile tables and charts, arranged for easy reference. The booklet may be obtained without charge by writing on company letterhead to Mr. H. M. Block, vice president, at the Hoboken main laboratory, or to any of the firm's branch laboratories in Boston, Providence, Philadelphia, Wilmington, Chicago, Memphis, Denver, Los Angeles, Dallas, and San Angelo, Texas.

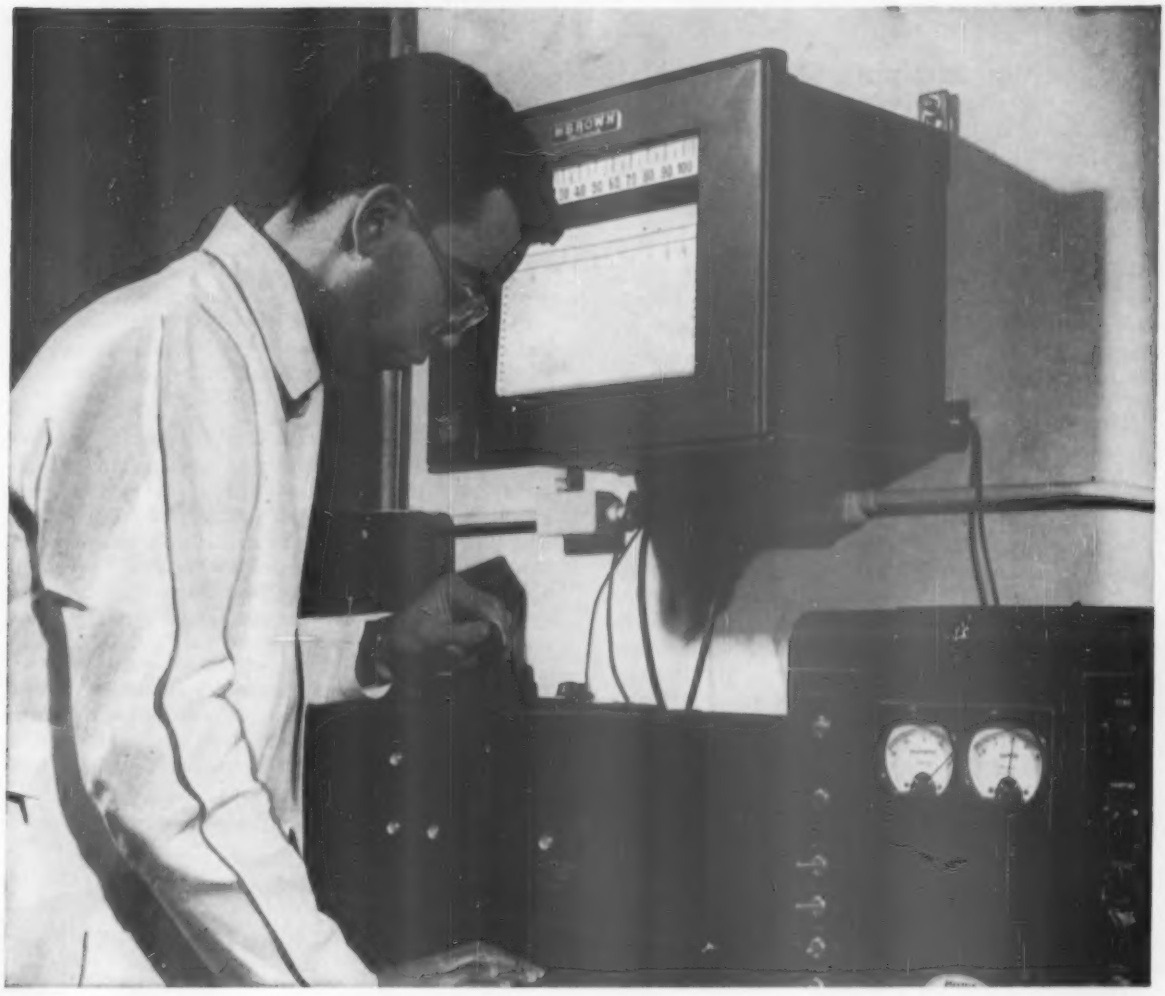
◆ ◆ ◆

"Brine for Today's Industry" is the title of a new booklet on the Lixate Process available from Industrial Division, International Salt Co., Inc., Scranton, Pa. The 32-page booklet replaces "The Lixate Process for Making Brine"—a standard reference for brine users for many years.

◆ ◆ ◆

The May 1955 issue of *Food Technology in Australia*, official organ of the Council of Australian Food Technology Associations, serves up such interesting sounding articles as "Chemical Changes in Dehydrated Milk During Storage," "Metal Foil Insulation for Canning Retorts," and "Blackneck in Tomato Sauce." Office for the 64-page, 6" by 9" monthly

(Continued on page 38)



He's taking a picture of a flavor!

This scientist is operating an infra-red spectrophotometer at American Can Company Laboratories.

He is analyzing a citrus juice sample to determine what *flavor* changes have taken place. Here's why:

Orange juice gets its distinctive flavor from peel oil. In the fresh fruit, juice and peel are kept separate; they are mixed during the canning operation.

The problem

Flavor changes during storage are due to chemical reactions between the peel oil and the acid of the juice.

The problem is to prevent that flavor from changing.

Canco scientists use the spectrophotometer to study effect of storage temperature and acidity on rate of change.

First, a freshly purified sample is tested through the spectrophotometer. The instrument delivers a graph which provides a record to test all new samples against.

Graphs are compared

Graphs for other samples are compared with the standard, and extent of flavor change is measured.

Orange juice research is but one of the many scientific projects studied by American Can Company in an effort to help canners develop the finest possible techniques.

AMERICAN CAN CO.

CANCO

NEW YORK
CHICAGO
SAN FRANCISCO

FOOD INDUSTRY TOPICS

(Continued from page 36)

publication is at 12 O'Connell St., Sydney, N.S.W., Australia.

A 48-page, hard-cover book giving extensive engineering and application information on Sandvik Steel-Belt Conveyors is available from Sandvik Steel Belt Conveyors, Division of Sandvik Steel, Inc., 1702 Nevins Rd., Fair Lawn, N. J. Fully illustrated, the book describes basic features of the conveyor and the steel belt, and gives details on characteristics, capacities, adaptations, and design. Properties of both stainless and carbon belts are discussed, and a list of standard widths and thicknesses for both single and longitudinally jointed belts is given. Load capacities of various widths of belt as applied to specific types of materials are indicated.

A complete set of new bulletins (Nos. 40, 41, 42, 43, 44, and Price Lists) from The Flexaust Co., 100 Park Ave., New York 17, N. Y., will be of interest to anyone concerned with the design, installation, or purchase of flexible hose used in dust and fume control, air-conditioning, and materials handling.

Evans Chemetics, Inc., 250 E. 43rd St., New York 17, N. Y., offers data sheets on all of the firm's organic sulfur compounds, mercaptans, sulfides, and mercapto acids.

A 19-page report on "Comparative Properties of Protective Coatings" by Gerald F. Gilbert, Jr., is available from The Atlas Mineral Products Co., Mertztown, Pa. The report contains information on 14 types of coatings used widely to protect equipment, walls, beams, and ceilings in plants where fumes and industrial atmospheres cause corrosion.

"Colloids Out of the Sea," an 8-page brochure describing some interesting uses for SeaKem Colloids —in ice cream, puddings, chocolate milk, toothpaste, and other food, drug, cosmetic, pharmaceutical, and industrial products—is offered by Seaplant Chemical Corp., 63 David St., New Bedford, Mass.

American Wheelabrator & Equipment Corp., 1095 S. Byrkit St., Mishawaka, Ind., is publishing a quarterly brochure devoted to precision cleaning and finishing. It deals with the wet abrasive blast process. The first issue contains a complete discussion of the scope of the wet blasting process and the diversity of applications it can serve. The firm will put persons on its mailing list for the publication, upon request.

A new reference guide and chart explaining the multiple uses of special chemical sealants in a variety of industrial, manufacturing, processing, agricultural, and maintenance operations has been published by the Industrial Division of Permatex Co., Inc., P. O.

(Continued on page 40)

Is a link missing in your Quality Control Chain?

But he can *be prepared* in advance to spot the trouble *the moment it occurs* by using

cook chex

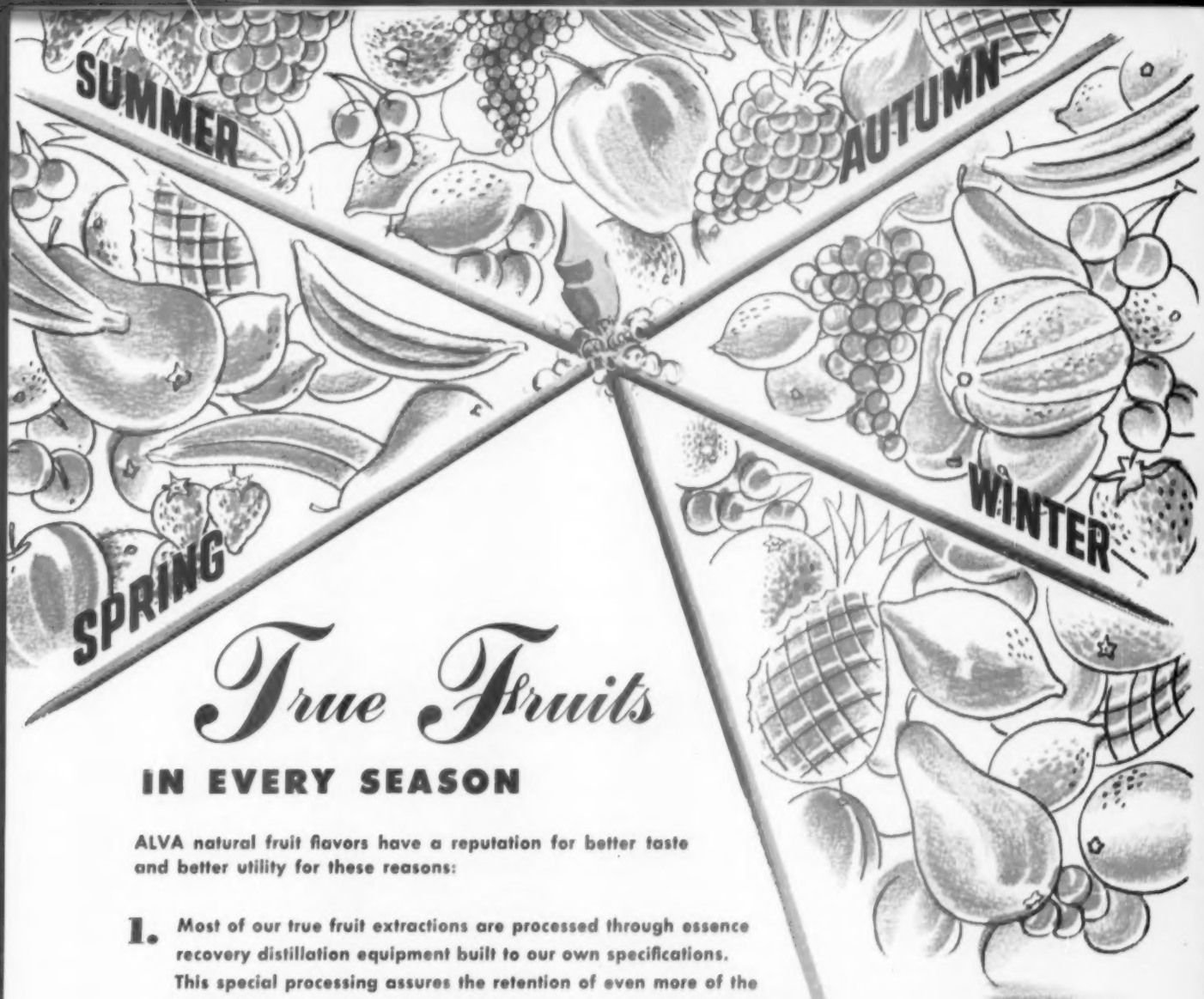
No Food Technologist can tell *in advance* when a batch is going to "go bad."

...PERATURE SPECIFICATIONS FOR FREE COOK-...ATORS CUSTOM-MADE TO FIT YOUR REQUIREMENTS

COOK-CHEX
11471 Vanowen St. North Hollywood, Calif. FT-9

Without obligation, please send me a supply of COOK-CHEX indicator tags designed for use at _____ degrees F., for _____ minutes.

Name _____
Position _____ Company _____
Address _____
City _____ State _____



True Fruits

IN EVERY SEASON

ALVA natural fruit flavors have a reputation for better taste and better utility for these reasons:

1. **Most of our true fruit extractions are processed through essence recovery distillation equipment built to our own specifications. This special processing assures the retention of even more of the light fugitive esters so difficult to hold in normal extraction procedures.**

2. **Storage facilities are maintained under ideal control conditions, improving the life of flavors and guaranteeing freshness in each delivery.**

3. **Through the years ALVA has developed procedures for handling fresh fruit which assure 100% purity.**

ALVA true fruit flavors are ideal for every use, and the ALVA laboratories are eager to help with recommendations and samples for every true fruit problem.

VAN AMERINGEN-HAEBLER, INC.

521 WEST 57th STREET, NEW YORK 19, N. Y.

Alva FLAVORS

FOOD INDUSTRY TOPICS

(Continued from page 38)

Box 1, Brooklyn 35, N. Y. The guide describes the proper sealants for use in hundreds of industrial applications. Failure to use proper and effective sealants to prevent leakage and seepage reportedly costs industry more than $1,000,000,000 per year.

◆ ◆ ◆

Publication of a 16-page stainless steel Engineering Data Book is announced by Cooper Alloy Corp., Hillside, N. J. Compiled for use as part of the new Cooper Alloy Catalog, the Engineering Data section includes design and dimensional information and a detailed materials selection chart covering over 300 corrosive solutions.

◆ ◆ ◆

Two new hard-cover books, containing detailed information, technical data, and prices of both clad steel heads and carbon and alloy spun heads, have been published by Lukens Steel Co., Coatesville, Pa. The books contain formulae for estimating sizes, tolerances, data on machining, and information on weights as well as prices, and may be ordered through the firm's Marketing Service Office at $3 each.

. . . *meeting hall and conference room*

It was generally agreed by the panel at the nutrition discussion sponsored by the National Citizens Committee for the World Health Organization that a good nutrition program in an area where there seemed to be a nutritional problem consisted first in evaluating the diet the people were getting, and secondly in formulating an "action program" for improvement. The discussion was part of a 3-day series of Post Assembly Technical Sessions held early in June at the Rockefeller Institute for Medical Research as part of a week-long international health conference. The nutritional discussions were chaired by Dr. H. D. Kruse, executive secretary of the Committee on Public Health of the New York Academy of Medicine. Participating were Prof. C. G. King, scientific director of the Nutrition Foundation; Dr. N. Jolliffe, director of the Bureau of Nutrition of New York City's Department of Health; and Dr. H. Pollack, associate professor of Clinical Medicine at New York University.

◆ ◆ ◆

Thirty-eight engineers from the chemical, pharmaceutical, petroleum, and food industries participated in the Eighth Seminar of Corrosion Resisting Process Equipment, presented in June by The Pfaudler Co., Rochester, N. Y. In his remarks to the group, Pfaudler Vice President D. A. Gaudion viewed corrosion as one of the critical technical problems facing industry today. He ascribed this situation to an accelerated corrosion rate for most types of processing equipment due to the elevated temperatures and pressures required to speed processing time. A total of 243 engineers from over 100 firms have attended the seminars since they began in 1953. Next in the series is scheduled for this fall.

◆ ◆ ◆

Meeting to study the mechanics and techniques of the institutional food industry, more than 200 wholesalers representing grocery houses in seven southeastern states attended the Institutional Sales School on June 4 in Richmond, Va. The School, sponsored jointly by Taylor and Sledd, Inc., and Can Manufacturers Institute, was termed a success by "students" and "faculty" alike. Among the latter was IFT member Russell Kraemer, general manager, Institutional Products Division, General Foods Corp.

◆ ◆ ◆

Oakite Chlor-Tergent, a new compound that cleans, deodorizes, and sanitizes, will be featured by Oakite Products, Inc., 19 Rector St., New York City, at Booths 171 and 173 at the Baking Industry Exposition in Atlantic City, October 1-6. Oakite also will exhibit compounds for bread and cake pan cleaning, and for cleaning tinned and aluminum surfaces; the Oakite Solution-Lifting Steam Gun for equipment cleaning; scale and slime preventives and removers; paint strippers and rust removers; floor cleaning compounds; Oakite Highlite for brightening equipment surfaces, and Oakite Bactericide and Sanitizer No. 1 for sterilization of equipment. Mr. Ken C. Tucker, manager of the firm's Food Industries Division, will be in charge.

. . . *building up and branching out*

Foxboro instrumentation for Asiatic industries shortly will be available through the Yokogawa Electric Works, Ltd., Tokyo, Japan, according to announcement by Mr. B. H. Bristol, Foxboro president. The Japanese firm will manufacture and sell the full Foxboro line, as well as its own electrical strip chart instruments. Foxboro-YEW products will be identical in design, appearance, and performance to those manufactured at Foxboro, Mass., and at associated firms in London and Montreal. Industries that operate internationally can thereby select the most convenient point of supply in line with currency available and delivery considerations.

◆ ◆ ◆

Construction of American Can Company's new factory at Arlington, Texas, expected to start in August on a 12.2-acre site, was announced by Mr. M. P. Cortilet, vice president in charge of the company's Central Division. The new 185,000 square foot plant will employ about 170 people, and will have an annual rated capacity for 300,000,000 fruit, vegetable, meat, and shortening cans.

◆ ◆ ◆

Mr. Frank Greenwall, president of National Starch Products, Inc., 270 Madison Ave., New York 16, N. Y., announced that the firm's second polyvinyl resin plant started operation in Meredosia, Ill., in July. While the prime function of the new plant will be to produce polyvinyl emulsion, it also is planned to manufacture adhesives containing large proportions of the vinyl emulsions for the company's National Adhesives Division. Mr. Greenwall also announced the beginning of construction on a 30,000 square foot addition to the present Alexander Research Laboratories in Plainfield, N. J.

◆ ◆ ◆

A "new look" for the trademark Cryovac has been adopted by the Dewey and Almy Chemical Co., divi-

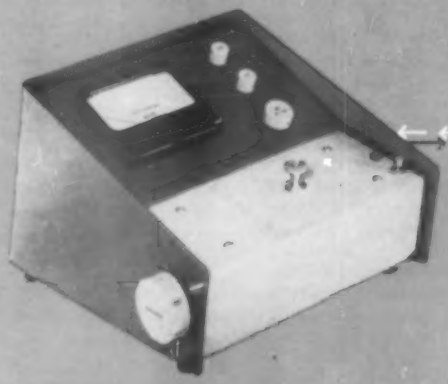
(Continued on page 42)

sugar

WHITENESS

-without guesswork

The Beckman Sugar Colorimeter removes all doubt about the whiteness of sugar. No longer do you have to depend upon visual judgment or expensive laboratory methods. Designed for laboratory precision, this relatively inexpensive instrument is so simple to operate that unskilled laboratory personnel can learn to use it accurately in less than an hour. A turn of a three-position dial gives percent light transmittance readings at the 420, 560, and 720-millimicron wavelengths, instantly without fuss or bother. These readings pinpoint sugar whiteness exactly. Whether your product is confectionery, bakery goods, or beverage, sugar whiteness can profoundly influence its acceptability—and you need the Beckman Sugar Colorimeter.



Write for Data File 55-84

Beckman Division

BECKMAN INSTRUMENTS, INC. • *Fullerton, California*

FOOD INDUSTRY TOPICS

(Continued from page 40)

sion of W. R. Grace & Co., 62 Whittemore Ave., Cambridge, Mass. Cryovac is Dewey and Almy's trademark for materials used in its process for vacuum-sealing meat, poultry, and cheese products. The new trademark design was developed to help packers capitalize on the growing consumer acceptance of vacuum-sealed meat and dairy products. The design features the words "Vacuum Sealed" along with the word Cryovac.

◆ ◆ ◆

Latest major food concern to enter the frozen food field is Carnation Company, 5045 Wilshire Blvd., Los Angeles 36, Calif., which has purchased Mrs. Lee's Pies, Inc., Los Angeles, makers of "Simple Simon" brand frozen fruit, cream, and meat pies and cookie rolls. Carnation will integrate Mrs. Lee's Pies, Inc., into its organization as the Frozen Food Division, with Mr. Andrew G. Read, president of the pie firm, as general manager.

◆ ◆ ◆

In anticipation of greatly increased sales because of new products, Seymour Foods, Inc., Topeka, Kans., has established a new Bakery Division through which the firm plans to market a family of egg products that it states promise to revolutionize production methods in the cake bakery industry. It is believed the products will be available in the east by this fall, and nationally some time in 1956.

◆ ◆ ◆

A new regional sales office to serve the Western and Northwestern states was announced by Mr. Richard S. Perkin, president of The Perkin-Elmer Corp., Norwalk, Conn. The office, located in the Citizens National Bank Bldg., North Marengo St., Pasadena, Calif., will handle sales and service of the firm's line of process control and standard laboratory instruments. Personnel will include Mr. W. C. Loe, for sale of process control equipment, Mr. T. A. Guerin, for sale of laboratory instruments, and Mr. A. W. Ehm, service engineer.

◆ ◆ ◆

New horizons for further growth and diversification of the Fuller Co., Catasauqua, Pa., are foreseen by Mr. Spencer D. Moseley, assistant to the president of General American Transportation Corporation as a result of Fuller's recent affiliation with GATC, of which it now is a subsidiary. "The dynamism of the Fuller-GATC combination," Mr. Moseley told an audience of Fuller sales, management, and technical executives, "will take us into new fields for the use of Fuller's pneumatic conveying systems, rotary air compressors and vacuum pumps, coolers and preheaters."

. . . *the human element*

Mr. Eugene E. Rhodes has been named manager of the Soybean Division of A. E. Staley Mfg. Co., Decatur, Ill., it was announced by Mr. E. K. Scheiter, executive vice president. A Staley employee since 1928, and acting Division head since last December, Mr. Rhodes will fill a position vacated by Mr. Paul Ray, who resigned to become vice president of Burrus Feed Mills, Inc., Dallas, Texas.

FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

1955

September 11-16	American Chemical Society, Minneapolis, Minnesota
September 14-16	American Fisheries Society, Augusta, Georgia
October 19-21	Symposium on Applications of Radioactivity in the Food and Food Processing Industries, Sheraton-Plaza Hotel, Boston, Massachusetts
October 19-21	First International Conference on the Use of Antibiotics in Agriculture—Sponsored by the National Academy of Sciences—National Research Council, Washington, D. C.

(Information concerning future dates of national and international meetings, conventions and exhibits of interest to food technologists should be sent to the editorial office.)

IDEAS FOR IFT EMBLEM WANTED

The Executive Committee of the Institute of Food Technologists has been given the task of selecting a design for an Institute emblem or insignia. President Clifcorn requests all members who so desire to submit suggestions. It should be borne in mind that the design should in some way depict or symbolize the principle objectives of our Society; namely, "The application of science and engineering to the production, processing, packaging, distribution, preparation and utilization of foods."

Pencil sketches are acceptable. Designs should be submitted to the Executive Secretary, 176 West Adams Street, Chicago 3, Illinois, before November 22, 1955.

Advertisers' Index

	Page
Abbott Laboratories	Following Page 10
American Can Company	37
Aseptic Thermo Indicator Company	38
Ass'n of American Soap & Glycerine Producers, Inc.	25
Bausch & Lomb Optical Company	31
Beckman Instruments, Inc.	41
Distillation Products Industries	6 and 7
Dodge & Olcott, Inc.	15
Eastman Chemical Products, Inc.	3rd Cover
Firmenich, Inc.	17
Florasynth Laboratories, Inc.	27
Food Development Laboratory	44
Food Machinery & Chemical Corp.	2nd Cover
Food Research Laboratories, Inc.	44
Fritzsche Brothers, Inc.	23
Givaudan Flavors, Inc.	9
Griffith Laboratories, Inc.	29
Hoffmann-La Roche, Inc.	4
LaWall & Harrisson	44
Magnus, Mabee & Reynard, Inc.	35
Morton Salt Company	33
National Aniline Division	19
The Nestle Company	13
Niagara Blower Company	28
Norda Essential Oil & Chemical Co.	4th Cover
Chas. Pfizer & Company, Inc.	21
Polak's Frutal Works	32
Schwarz Laboratories, Inc.	44
Shell Chemical Corporation	3
A. E. Staley Mfg. Co.	43
Sterwin Chemicals, Inc.	1
Sunkist Growers, Inc.	11 and 30
Truesdail Laboratories, Inc.	44
S. Twitchell Company	36
Ungerer & Company, Inc.	24
van Ameringen-Haebler, Inc.	39
Wisconsin Alumni Research Foundation	44

FOOD INDUSTRY TOPICS

Mr. Russell L. Putman, president and publisher of Putman Publishing Co., 111 E. Delaware Pl., Chicago, Ill., has announced promotion of **Mr. Chas. H. Oestmann** to vice president. Mr. Oestmann has been sales manager of *Food Processing* magazine for the past two years, and has been affiliated with the company since 1946. He will headquarter in the Chicago executive offices.

Mr. Oestmann

◆ ◆ ◆

National Dairy Research Laboratories, Inc., Oakdale, N. Y., announces the following appointments: **Mr. Thos. Bonnitt** and **Mr. Alvin Holzberg** to the staff of the Commercial Development Dept.; Mr. Jules Guth to the staff of the Dairy Products Laboratory; and Miss Sally Moore as bacteriologist on the staff of the Fundamental Research Laboratory.

◆ ◆ ◆

Mr. Percy C. Magnus, president, and **Dr. Henri F. Logcher,** export manager, Magnus, Mabee & Reynard, Inc., Desbrosses St., New York City will sail on the S. S. UNITED STATES on September 2 for England and the Continent. They will confer with company agents and customers as part of an intensive drive to increase MM&R's already important share of the European market. The trip is coordinated with the MM&R Diamond Jubilee.

From MM&R also comes word of the latest edition of the firm's king-size (24 pg.) catalog, which has been completely revised and supplemented with additional information about many of the products. For free copy, write the MM&R Advertising Department at the above address.

Pennsylvania Salt Mfg. Co., now located in its modern new headquarters at 3 Penn Center Plaza, Philadelphia 2, Pa., announces promotion of **Mr. J. Stanley Hall** to sales director of the Chemical Specialties Division. **Mr. Paul C. Hurley,** manager of advertising and sales promotion since 1950, succeeds Mr. Hall as sales manager of the laundry and dry cleaning department.

◆ ◆ ◆

Mr. Ernest Nuber has been promoted to general field sales manager for The Bristol Co., Waterbury 20, Conn., according to announcement by Mr. Harry E. Beane, vice president in charge of sales.

◆ ◆ ◆

Mr. Wm. S. Rheem II, general manager of the Rheem Mfg. Co., 7600 S. Kedzie Ave., Chicago 29, Ill., has been elected to the corporation's board of directors and named a vice president, it was announced by President R. S. Rheem. The company, founded in 1925, is the world's largest producer of water heaters and steel containers.

◆ ◆ ◆

Mr. B. E. Schaar, president and founder of Schaar and Co., Chicago, retired July 1. Under his leadership since 1909, the firm has become nationally recognized as suppliers of chemical laboratory equipment. **Mr. C. E. Schaar** was elected president, and **Mr. L. A. Rauch** was elected executive vice president. B. E. Schaar will continue to serve on the board of directors.

◆ ◆ ◆

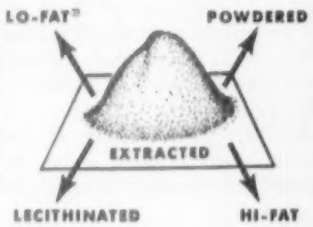
Two new appointments at the Central Laboratories of General Foods, Hoboken, N. J., were announced by Mr. Harvey Murer, manager of the laboratories. **Mr. John R. Lowry** has been promoted to project leader in radio chemistry, and **Mr. Arnold J. Kaminer** has joined the laboratories as a junior technologist.

Mr. Geo. C. Borden, Jr., technical director of Riegel Paper Corp., 260 Madison Ave., New York 16, N. Y., died of a heart attack on July 8 at age 54. Over a period of many years, he served on numerous committees of the American Paper & Pulp Assn., The Technical Assn. of the Pulp & Paper Industry, The

Staley's®

Products from Corn and Soybeans

...from Insecticide Sprays to Linoleum to Bakery Goods



SOY FLOURS

A boon to bakers and the food processing industry, Staley's Soy Flours add high quality protein value to all food products. (2 lbs. of Staley's Soy Flour pack the protein content of 6 dozen eggs). Soy flours help to retain moisture and freshness, add to body and texture, and bring out color and flavor. Lecithinated soy flour supplies needed emulsifier and antioxidant properties. Staley's Soy Flours offer desirable properties to industrial users, too, in paint, insecticide, linoleum, plywood, and paper coating fields.

Processed by special solvent extraction methods, 5 kinds of Staley's soy flours are available. Your Staley representative will be glad to discuss your needs and recommend the grade best suited for your processes. Or write for complete data.

For information about other quality Staley industrial products: Lecithin, Starches, Corn Steep Liquor, Corn Syrups, Soy Oils, etc., write:

A. E. STALEY MFG. CO.
DECATUR, ILLINOIS

FOOD INDUSTRY TOPICS

Glassine and Greaseproof Assn., and various other organizations.

◆ ◆ ◆

Mr. Wm. Schilling, Jr., an officer and secretary of Norda Essential Oil and Chemical Company, Inc., New York City, died July 15 at age 63. With the firm for 25 years, he had served as president of the Vanilla Bean Assn., and the Essential Oil Assn. of the U. S.

◆ ◆ ◆

Mr. D. K. Howe, president of Fairmont Foods Co., 3201 Farnam, Omaha, Nebr., has moved up to the position of chairman of the Board. New president, replacing Mr. Howe, is **Mr. John A. Robins,** formerly administrative vice president of Stokely-Van Camp Co., Inc. **Mr. L. E. Hurtz,** present Board chairman, is retiring from active duty and will be honorary chairman of the Board.

EMPLOYMENT NOTICES

WANTED: PRODUCT DEVELOPMENT—Opportunity for Food Technologist to work in product development field for national food manufacturer in Chicago. Should have 5 to 10 yrs. exp. in food product development with emphasis on frozen foods. Between 30 and 45, in good health. Must have imagination, ability to work well with others and successful record in the field of product development. Replies will be held in confidence. Send resumé with recent snapshot to **BOX 424**, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

WANTED: DIRECTOR OF PRODUCT RESEARCH AND DEVELOPMENT. Food Technologist with some knowledge of chemistry. Should have 5 to 10 yrs. exp. in baking industry or allied food field. Between 32 and 40. Should have creative imagination, display initiative, be self-starter, have ability to handle and direct activities of others and approach research and development problems from practical rather than scholarly viewpoint. Salary open. REPLY BOX 432, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

FOOD TECHNOLOGISTS
An active, confidential service: Interview at your convenience, Call, write or wire:
Gladys Hunting (Consultant)
Drake Personnel, Inc.
Room 628
HArrison 7-8600
220 S. State St., Chicago 4, Ill.

AVAILABLE: CUSTOMER SERVICE AND/OR TECHNICAL SALES DIRECTOR. Chemist and Food Technologist of recognized stature in the food industry, with outstanding record of achievement in the field of technical service and sales, seeks opportunity to organize and/or direct a department to serve the food industry. Although most specifically trained in the field of edible fats and oils, experience is sufficiently broad to do outstanding job with practically any types of food products or materials. REPLY BOX 431, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

AVAILABLE: PRODUCTION AND RESEARCH CHEMIST, with extensive and diversified experience in production, supervision, development and control of confectionery, desserts, cereal products, chocolate, ice cream, bakery products and other foods, desires position of responsibility. REPLY BOX 434, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

POSITION WANTED: Recent Ph.D. in Food Tech. wants permanent position as research Food Technologist or manager of Food Plant. Supporting fields of study are Biochemistry and Horticulture. Minimum salary desired $6,000 annually. REPLY BOX 435, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

FOOD DEVELOPMENT LABORATORY
S. W. ARENSON
Director
2865 West Franklin St.
Baltimore 23, Md.
440 W. 24th St.
New York, N. Y.
Ingredient evaluations • New products development — flour, shortenings, milk and other basic ingredients • Chemical and physical laboratory, bakery, spray dryer and other unit process equipment.

PRODUCTION CONTROL SERVICES
Vitamin D rat assay — results in 8 days • U.S.P. or A.O.A.C. vitamin A assays • Other vitamin assays • Antibiotic and amino acid assays • Sodium determinations • Proximate analyses and mineral determinations. • Pharmacology including warm-blooded toxicity studies • Specific immune sera • Enzyme investigations • Insecticide Testing and Screening
Other biological, chemical, and microbiological services.
Project Research and Consultation.
WISCONSIN ALUMNI RESEARCH FOUNDATION
P.O. Box 2059-S • Madison 1, Wisconsin

Schwarz
SERVICES TO THE FOOD INDUSTRIES
• Consultation on Food Problems.
• Analyses of food materials and products.
• Food plant design, process examination and control.
• Legal testimony and consultation on government regulations.
Founded 1867
Write for bulletin "Scientific Quality Control of Foods and Beverages"
SCHWARZ LABORATORIES, Inc.
230 Washington St., Mount Vernon, N. Y.

TRUESDAIL Laboratories, Inc.
Research Analyses Testing Foods, Drugs Allied Products
CHEMISTS • BACTERIOLOGISTS • ENGINEERS
Charter Member ACIL

Food Ingredient & New Drug Studies
BIOLOGIC ASSAYS
LaWall & Harrisson

FOOD RESEARCH LABORATORIES, INC.
Founded 1922
Philip B. Hawk, Ph.D., President
Bernard L. Oser, Ph.D., Director
Research • Analyses • Consultation
PLANT AND PRODUCT INSPECTIONS
Biological, Nutritional, Toxicological Studies for the Food, Drug and Allied Industries
48-14 33rd Street, Long Island City 1, N. Y.

CHEMIST or FOOD CHEMIST
RECENT GRADUATE with B.S. DEGREE
Research & development work on Soluble coffee.
Attractive opportunity
Well Established
Food Company
Metropolitan area.
Send complete resume.
BOX No. 433
INSTITUTE OF FOOD TECHNOLOGISTS
176 W. Adams Street
Chicago 3, Illinois

All these **Eastman antioxidants** to help you protect food products against oxidative deterioration . . .

ANTIOXIDANT	PERCENTAGE COMPOSITION (BY WEIGHT)						
	Butylated Hydroxy-anisole	Butylated Hydroxy-toluene	Propyl Gallate	Citric Acid	Mixed Glycerides	Vegetable Oil	Propylene Glycol
TENOX BHA **Application:** Vitamin A, chewing gum base, food packaging materials, paraffin wax, polyethylene.	100						
TENOX BHT **Application:** Paraffin wax, polyethylene, food packaging materials, vitamin A, citrus and essential oils.		100					
TENOX PG **Application:** A compound, water-soluble in effective amounts, which produces high AOM stabilities.			100				
TENOX II **Application:** Lard, animal fats, vegetable oils, potato chips, spices, cosmetics, nuts.	20		6	4			70
TENOX IV **Application:** Lard for pastry, crackers, vegetable oils and candy where good carry-through stability is desired.	20	20				60	
TENOX VI **Application:** Designed to provide maximum stability to lard under Meat Inspection Regulations. Also useful in stabilizing vegetable oils, potato chips, cereals and nuts.	10	10	6	6	56		12
TENOX VII **Application:** A high concentration of antioxidants dissolved in an extra soluble solvent combination for easy addition where suitable agitation equipment is not available.	28		12	6	20		34
TENOX R **Application:** Tallows and greases for animal feeds.	20			20			60
TENOX S-1 **Application:** Provides high AOM stability. Vegetable oils, potato chips.			20	10			70

Don't let rancidity, bad odor and off-flavor cause returns, losses and dissatisfied customers. Use Tenox antioxidants to protect sensitive foods against oxidative deterioration.

Antioxidants are simple to use . . . inexpensive to use. As their name indicates, they retard the natural oxidative breakdown of fats and oils which in turn causes rancidity. Their value has been proved on a wide range of food products. Every year finds antioxidants playing a bigger role in food protection.

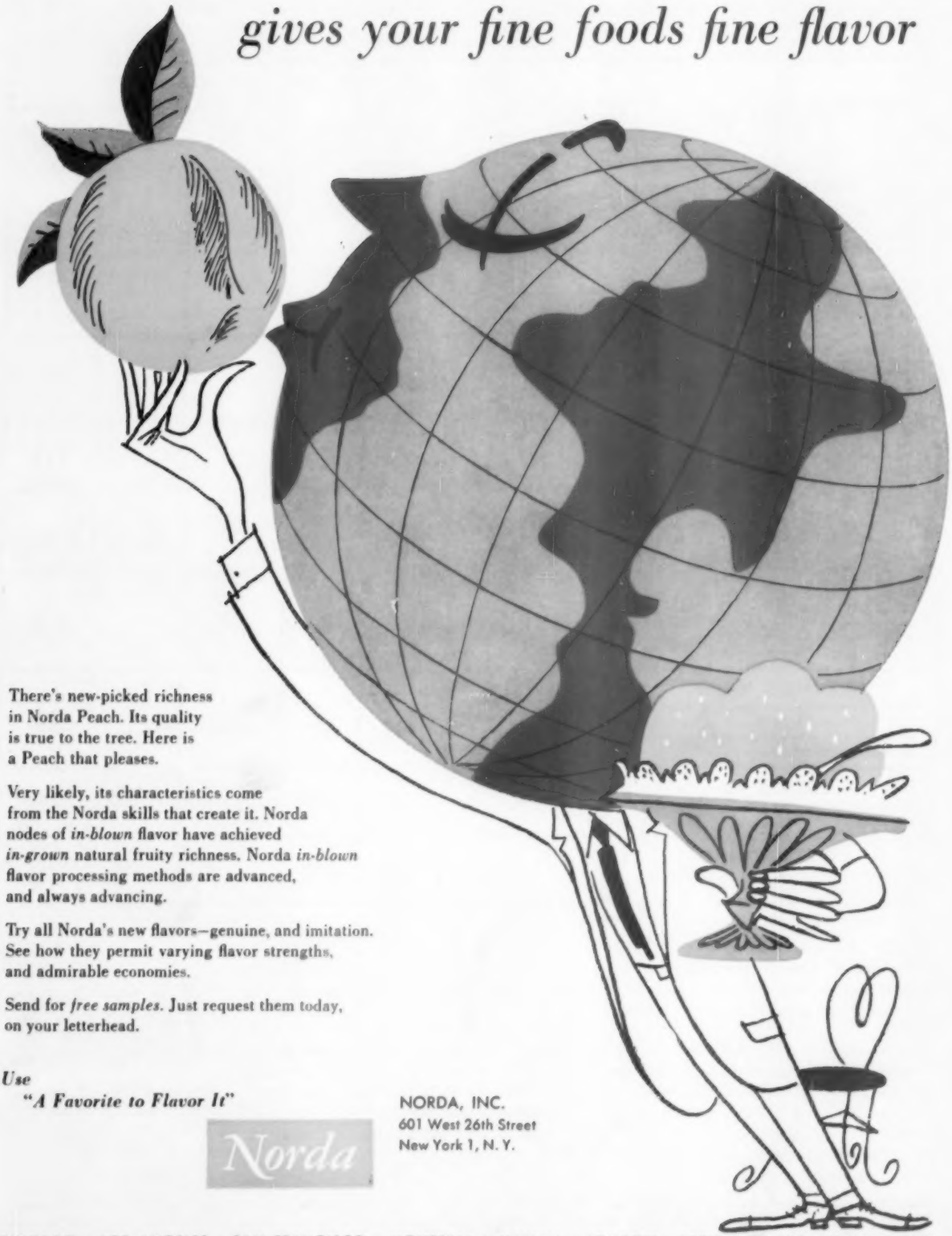
Can antioxidants help you? Call on Eastman if you would like to investigate the use of antioxidants to stabilize your food products. Eastman is the leader in food-grade antioxidants. The leader in volume . . . in experience . . . in accumulated data. Write to Eastman Chemical Products, Inc., a subsidiary of Eastman Kodak Company, Kingsport, Tennessee.

Tenox

Eastman food-grade antioxidants

SALES OFFICES: **Eastman Chemical Products, Inc.,** Kingsport, Tenn.; New York—260 Madison Ave.; Framingham, Mass.—65 Concord St.; Cincinnati—Carew Tower; Cleveland—Terminal Tower Bldg.; Chicago—360 N. Michigan Ave.; St. Louis—Continental Bldg.; Houston—412 Main St. **West Coast: Wilson Meyer Co.,** San Francisco—333 Montgomery St.; Los Angeles—4800 District Blvd.; Portland—520 S. W. Sixth Ave.; Salt Lake City—73 S. Main St.; Seattle—821 Second Ave.; **Canada: P. N. Sodon Co., Ltd.,** Montreal, Quebec—2143 St. Patrick St.; Toronto, Ontario—1498 Yonge St.

This peach with its fresh orchard taste gives your fine foods fine flavor



There's new-picked richness in Norda Peach. Its quality is true to the tree. Here is a Peach that pleases.

Very likely, its characteristics come from the Norda skills that create it. Norda nodes of *in-blown* flavor have achieved *in-grown* natural fruity richness. Norda *in-blown* flavor processing methods are advanced, and always advancing.

Try all Norda's new flavors—genuine, and imitation. See how they permit varying flavor strengths, and admirable economies.

Send for *free samples*. Just request them today, on your letterhead.

Use
"A Favorite to Flavor It"

Norda

NORDA, INC.
601 West 26th Street
New York 1, N. Y.

CHICAGO • LOS ANGELES • SAN FRANCISCO • MONTREAL • HAVANA • LONDON • PARIS • GRASSE • MEXICO CITY